PERIODICAL ROOM
GENERAL LIBRARY
UNIV. OF MICH

FEB 24 1931

Science Education

The Science Magazine for All Science Teachers

Formerly General Science Quarterly

... CONTENTS ...

	Page
National Council of Supervisors of Elementary Science	2
Program of the National Association for Research in Science Meeting	3
The Organization of the High School Biology Course. *E. E. Bayles*	75
A Technique for Developing Content for a Professional Course in Science for Teachers in Elementary Schools. *Florence Grace Billig*	82
New York State Science Teachers' Meeting	90
International Language for Science	90
An Analysis of the College Entrance Examination Board Examinations in Elementary Chemistry for 1921 to 1928. *Jacob W. Boorstein*	91
What Constitutes a Desirable Program of Studies in Science Education for Teachers of Science in the Elementary School? *E. Laurence Palmer*	101
The School Museum. *May Weber Smith*	111
Mathematics and First Year Chemistry. *B. Clifford Hendricks*	115
Abstracts	121
Nature's Method of Purifying Polluted Water	127
New Books and Monographs	128
Editorial Board	138

Published four times a year: in November, January, March and May
By W. G. WHITMAN, 350 Lafayette Street, SALEM, MASS.

Entered as second class matter Nov. 6, 1916, at Salem, Mass., under the Act of March 3, 1879

$1.50 a year
40c a copy

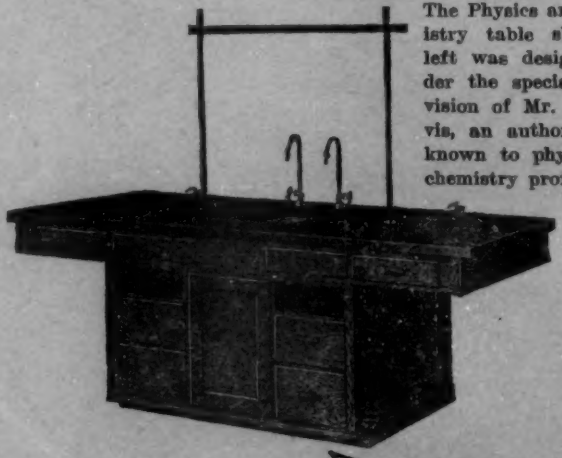
JANUARY, 1931

VOLUME 15
NUMBER 2

A practical man's idea

In material, workmanship, and finish it is always taken for granted that a Welch product is of the highest grade and that confidence is never misplaced.

In the designing of laboratory furniture, Welch goes to the extreme in following the suggestions of renowned Physicists. At the same time they rely considerably upon the recommendations of their own territorial representatives in all parts of the country, for Welch representatives are recognized as men of ability and experience in the most modern practices of famous Educators.



The Physics and Chemistry table shown at left was designed under the special supervision of Mr. Abe Davis, an authority well known to physics and chemistry professors.

No. 2574. Combination Physics and Chemistry desk for two students. Has many unique features appreciated by Instructors.

Made also for four students.

WELCH

Physics, Chemistry, Biology
Agriculture and General Science

Laboratory
FURNITURE
and Apparatus

1880 — Over Fifty Years of Service to Schools — 1931

W. M. WELCH MANUFACTURING COMPANY

GENERAL OFFICES: 1515 Sedgwick Street CHICAGO, ILLINOIS

LABORATORY FURNITURE FACTORY
MANITOWOC, WISCONSIN

SCIENTIFIC APPARATUS FACTORY AND WAREHOUSE
1516 ORLEANS ST., CHICAGO, ILLINOIS

BRANCHES:

342 MADISON AVE. NEW YORK CITY
1916 WEST END AVE. NASHVILLE, TENN.
34TH AND BROADWAY KANSAS CITY, MO.
2220 GUADALUPE ST. AUSTIN, TEXAS

SCIENCE EDUCATION

Devoted to the Teaching of Science in Elementary Schools, Junior and Senior High Schools, Colleges and Teacher Training Institutions

(Formerly GENERAL SCIENCE QUARTERLY)

Vol. XV JANUARY, 1931 No. 2

The Organization of the High School Biology Course

E. E. Bayles,
University of Kansas

Instruction in biological science has had a fairly well established place in the high school curriculum for about fifty years. Approximately a hundred years have passed since its first introduction into high school. Up to ten years ago this instruction was presented for the most part as the separate sciences of botany, zoology, and physiology.

The past decade, however, has witnessed the rapid rise of the unified subject of "biology" which attempts to cover, in an introductory way, the entire field of biology, including psychology. Allyn and Bacon, publishers of the text adopted by Kansas, report sixty-seven Kansas schools offering biology in 1925, and 285 in 1929.

This process of unification can be traced readily in the revisions of the various textbooks that have been on the market during the past decade. The first step was a definite division of the book into three parts—animal biology, plant biology, and human biology. This threefold classification is gradually disappearing, some books dispensing with it entirely as an organizing principle, while others have dropped the evidence from the table of contents, but still embody it in the arrangement of the chapters. The trend, however, seems unquestionably toward the unified arrangement.

The question arises as to whether this movement is sound from the viewpoint of organization. To the present writer the answer seems to be in the affirmative. The course that is properly organized for instructional purposes must be arranged in accordance with the principles of learning that are involved.

One of the first of these is that learning proceeds from the more generalized to the more specialized features of any subject. When one is introduced to a stranger, the first impressions are very general in nature—forcefulness of speech and manner, taste in dress, whether tall or short, large or small, light complexioned or dark, likeable or not. Few people would be able, after a two-minute conversation unless posted ahead of time, to tell the color of eyes, shape of head, minute details of dress, or other similar features, and only after a friendship of years is one able to penetrate into the inner recesses of thoughts, ambitions, and desires.

For the most economical learning, a subject should be approached in this same way—taking the broader, more fundamental features first, and proceeding to those that are more detailed, specific, or technical. This means that if the student, in his first introduction of biology, is to get an adequate, properly proportioned view of the field, he must see it in all its major phases. He must realize that he is studying life in whatever form it appears. The limiting process, division into botany, zoology, etc., must be postponed until this view has first been given. This type of approach is peculiar to, even if not always found in, the unified treatment.

Secondly, the course should be unified since it is thus permitted to treat of principles of biology in an adequate, well-proportioned way. Biological principles, at least those that are included in a beginner's course, are just as applicable in the field of plant biology as in animal or human biology,[1] and vise versa. All living things are designated as living because they are able to perform certain "life functions" in greater or lesser degree of simplicity and complexity. Too often students, as well as teachers, fail to see the significance of this essential unanimity of basic, governing principles.

In the third place, in order that a science course be practical and usable, it must be so taught that the greatest amount of transfer shall result. Probably the most serviceable concept of the method of transfer is science-type material is transfer by the process of generalization. Generalization is the realization of relationship. When relationships are seen, the individual is

1 And it is, of course, also true that this distinction between animal and human biology is very misleading to the beginner, since one is really a phase of the other.

able to react intelligently to the situation involving this relationship. To develop in the student the ability to do this, the course must be taught as a series of principles, since principles are statements of relationship, either as verbal formulation or tacit realization. All facts need to be presented in such a way as to show their bearing on other facts, not as separate entities in themselves. Logical memory has been shown to be far more effective than memory for discrete materials. Courses that are so organized are explanatory, in that they lead to the explanation of phenomena. When phenomena are explained it is but a relatively short step to control. The explanatory course is to be contrasted with the descriptive, which is entirely static. Explanation is dynamic in that it leads to prediction and control. Description is static since it merely presents facts as they are at a given instant, not as they may be a moment, an hour, or a week later.

If a one-year, beginning course is to give the student the fullest possible view of biological phenomena for the purpose of making it immediately useful and practical, it must give opportunity for viewing the application of the principles treated in as many and as widely varied instances as possible. This is more easily and effectively done in the unified course than in one that is compartmentalized.

Lastly, the unified course makes for more effective learning because it cuts down the number of separate concepts that must be developed. When the child learns a life principle in connection with animals during, say, the first third of the year, he seldom recognizes this same principle when brought up during the middle of the year in connection with plants, and again when brought up toward the close in connection with human biology. Too often the teacher fails to realize this fact. Thus, the number of concepts that must be learned is multiplied by three in the three-fold arrangement, making biology a much more complicated and difficult subject, besides committing the evil of shutting up the student's thinking into water-tight compartments, and failing to give him the realization of unity at the outset.

Biology courses at the present time are almost entirely descriptive. Biology laboratory exercises are the same. Drawings are the paramount outcome. Experiments which answer the question "what will happen if" are conspicuous for their

absence. The high school biology course of today is in need of reorganization into one which can truthfully be labeled an "Elementary Course in the PRINCIPLES of Biology." The following outlines present in a brief way a course which has been organized in accordance with the views just presented. Its primary purpose is to develop an understanding of the broad, fundamental principles of the science of biology. The order in which these principles are presented is the degree of their generality. Progress is from the more generalized to the more specialized phases.

A course, formulated on this basis, is one which departs rather radically from the one usually found in the high school, but it is one which appeals to the student as being greatly worthwhile and interesting. This particular one has been tried out in a score or more of classes and repeatedly revised on the basis of these tryouts.

The outline shows twelve units altogether, ten of which can be completed by the average student in a 36-weeks period. The two additional units can be used as special work for the faster students, and the completion of eight units may be considered as a minimum requirement for credit with the lowest mark, (barely passing work). This time allotment is required for real mastery of the principles involved in each unit, not for a superficial presentation. The writer has elsewhere[2] described a plan of testing whereby mastery may be measured with a reasonable degree of accuracy and objectivity.

I. The Nature of Living Things.
   1. How living things differ from non-living things.
   2. How living things are similar to non-living things.
   3. How complex living things differ from simple living things.

II. How Living Things are Adapted to Their Environment.
   1. How organisms are fitted for obtaining food—carnivorous vs. herbivorous adaptations—differences in structure as well as in ways of doing things.
   2. How organisms are fitted for protection—by flight; by defense; by armor or other coverings; by coloration and mimicry.
   3. How social behavior is an adaptation both for protection and for food getting.

---

2 Bayles, E. E., "Testing for Comprehension"; Journal of Educational Research, Vol. XX, No. 4, pp. 268-72, Nov., 1929. Bayles, E. E., "Fundamentals in High School Science Teaching"; Bulletin of the Central Missouri State Teachers College, Warrensburg, December, 1927, Chapter IV.

III. How Plants are Adapted for the Manufacture of Food.
1. How food is manufactured.
Leaf structure—raw materials—products—conditions.
2. How raw materials are taken from the soil.
Root structure—osmosis—etc.
3. How food-making materials are transported from one part of the plant to another.
Stem structure and growth—monocot and dicot—arrangements of stems and leaves for providing maximum light, etc.
4. How non-green plants obtain food.
Saprophyte and parasite relationships; symbiosis.

IV. How Living Things Use Their Food—I. (Digestion and Circulation.)
1. How food is prepared for use (digestion).
Need for digestion—organs used in higher types—organs present in lower types. Use worm, rabbit, cow, bird, earthworm, hydra and amoeba and plants for illustrative purposes.
Chemical and non-chemical digestion.
2. How food is distributed to the cells. (Absorption and circulation.)
Highly developed circulatory systems, nature of the blood, etc.—lower type of systems—plant systems.
Absorption and osmosis.

V. How Living Things Use Their Food—II. (Assimilation; Energy Production; Storage; Excretion.)
1. How food material is made into cell structure.
Materials needed—material produced—wastes—rapidity of action as influenced by exercise.
2. How food material is converted into energy.
Materials needed—wastes—comparisons to locomotive—effect of exercise—respiration. Comparison of high and low type organisms. Warm and cold blooded animals.
3. How surplus food is stored.
Storage of carbohydrates, fats, proteins. Organs in plants and animals. Condition of food material when in storage, regarding solubility in water.
4. How wastes are eliminated.
From assimilation and energy production—organs employed—higher and lower forms of excretory systems.
Plants—transpiration—acid excretions into soil and effect on insoluble soil salts.

VI. The Conservation of Our Biologic Wealth.
1. Conservation through the maintenance of soil fertility.
Available and unavailable foods—making foods available—fallowing—fertilizing and fertilizers—rotation of crops—nitrogen cycle.
2. Conservation through the control of pests.
Nature of pests—natural control—artificial control—epidemics—immunity—establishing natural controls.
Balance of nature a needed condition.
3. Conservation through the protection of wild life.
Why an organism is protected—open and closed seasons, reasons for, and time for—game preserves—fish hatcheries—restrictions on land reclamation.
4. Conservation of forest resources.
Rate of use and decline of supply—present location of lumber supply and consequent problems—methods of conservation and development.

VII. Modification and Improvement of Plant and Animal Forms.

1. How heredity functions.
   Mendel's laws.
2. How man uses hybridization and crossing to effect changes.
   Luther Burbank—methods used—results.
3. How the natural environment produces changes.
   Variation, selection, survival—Darwin and Lamarck—DeVries and mutations.
4. How man uses selection to effect changes.
   Development of special types—method of selection—results.
5. How environment controls the degree to which the organism can live up to its possibilities.
   Effects of good and poor food, housing, disease, etc.
6. Evidences that changes have come about in past ages.
   Vestigal organs—physiological comparisons—embryonic development and life histories—fossil evidence.

VIII. How Living Things Maintain Their Kind.

1. How one-celled plants and animals maintain their kind. (Asexual methods.)
   Simple cell division—production of spores—budding.
   Number of individuals concerned—rapidity—etc.
2. How the higher forms provide for the maintenance of kind. (Sexual methods.)
   a. How pollination and fertilization are secured.
   Flower parts and uses—self and cross pollination—methods of preventing self pollination—fertilization—methods among animals, using fish as illustrative.
   b. How the fertilized egg develops into the adult.
   Embryonic development as shown by frog's egg—life histories of various organisms—insect metamorphoses—altricial and praecocial birds—oviparous and viviparous animals—seed germination and growth—conditions necessary—viability—dormancy—life histories of plants.
   c. How the young are cared for during dependency.
   Relationship between degree of development and length of infancy, care given young, number of offspring produced, helplessness at birth, etc. Seed dispersal in plants. The place of the home and family.
3. How natural and artificial shortcuts are secured in the propagation of plants.
   Cuttings—layering—grafting—budding—bulbs, tubers, etc.—decumbent stems—runners—underground shoots, etc.

IX. How Living Things Maintain Health.

1. How physical injuries are produced and cared for.
   Broken bones—ruptured or cut blood vessels—burns—tree surgery—etc.
2. How chemical injuries are inflicted and treated.
   Acid and alkaline poisoning—corrosive poisons—poisons affecting nervous tissue—CO poisoning, and effects of CO_2—etc.—poisoning is specific and requires skilled attention as soon as possible.
3. How organic disorders affect health.
   Nutritional and other functional disorders.
4. How parasitic action causes ill health.
   Infectious and contagious diseases—nature of bacterial action—the germ theory of diseases—how germs make one ill—methods of infection—etc.

5. How the body protects itself against germ attacks.
   The work of the phagocytes—general versus specific immunity—natural versus artificial immunity—vaccination, serum shots, toxin-antitoxin treatment—resistent varieties of plants—the skin and mucous linings as protectives.
6. How infection is kept away from the body.
   The problems of sanitation and municipal cleanliness—methods—man's chances for the banishment of disease.

X. The Control of Plant and Animal Behavior.
1. How the organism becomes aware of its surroundings.
   Irritability a life function—irritability in the amoeba—development of specialization in the intermediate forms—the various senses in the higher organisms—structural and functional comparisons.
2. How the simplest types of living things respond to stimuli.
   Simple, mechanical behaviors—reflexes and tropisms—physiological basis for this type.
3. How the intermediate types respond.
   Instinctive behavior—effect of experience and ability to learn—physiological bases.
4. How intelligent behavior differs from unintelligent behavior.
   Part played by memory—effect of training—reasoning and judgment—the superiority of human over non-human behavior—the human nervous system—comparison with other systems.

XI. How Living Things are Distributed Geographically.
1. Factors governing the distribution of aquatic forms.
   Temperature—depth—fresh and salt water—food supply.
2. Factors governing the distribution of terrestrial forms.
   Effects of moisture supply, temperature, barriers, etc., in determining life zones.
3. How natural causes effect changes in distributions.
   Effect of climatic changes, alteration of barriers, motility of the organism, etc.
4. How man has produced changes in distributions.
   By domestication of animals—clearing lands for agricultural purposes—industrial projects—attempts at pest control—etc.

XII. How Our Present Knowledge of Biology Has Developed.
1. How the men of early days began the study.
   Aristotle, Pliny, Galen, the Dark Ages.
2. How the first scientific study of the organization of the human body advanced biology as a science.
   Vesalius, Harvey.
3. How the introduction of the microscope opened new fields.
   Malpighi, Leeuwenhoek, Müller.
4. How the advantage of a uniform nomenclature for plants and animals has increased knowledge.
   Linnaeus.
5. Influence of comparative anatomy and cell theory.
   Cuvier, Bichat, Schwann.
6. How the discovery of protoplasm led to new investigations and solved old puzzles.
   Dujardin.
7. How the discovery of microorganisms influenced medical science.
   Leeuwenhoek, Spallanzani, Pasteur, Jenner, Woch, Lister, Reed.

A Technique for Developing Content for a Professional Course in Science for Teachers in Elementary Schools [1-2]

FLORENCE GRACE BILLIG

Supervisor of Science, Sacramento City Schools
Sacramento, California

A professional course in science may be interpreted as a course designed to train teachers for their work in science. In this study it is assumed that the subject matter in such a course will include the content to be used directly by the pupils on the grade level for which the teachers are being trained. In addition, it will include a body of content that may be used only occasionally by the pupils but which will give the teacher a background of information enabling him to guide the pupils to an understanding of the materials with which they are working, and at the same time will give the instructor that security in his teaching which comes only through adequate preparation. Such a course will provide a background of subject matter that has the richest possible educational value for the learner, as well as training for the professional work which the student will undertake later.

The point of view which has guided this study is that there are large principles[3] or general truths in the field of science that are significant in the general education of boys, girls, and adults, and which contribute to an understanding of the phenomena of the commonplace environment. These general truths may serve as guides in the selection and organization of content for a professional course in science.

A professional course as suggested in this study would be composed of a number of units each developed around a principle of science that would establish a goal toward which the study would be directed. A preliminary study[4] made by

1 This report was presented at the meeting of the National Association for Research in Science Teaching held in Atlantic City, N. J., February, 1930.

2 A detailed report of this study is given in the investigation made by Florence Grace Billig, "A Technique for Developing Content for a Professional Course in Science for Teachers in Elementary Schools." Contributions to Education, No. 397, 1930, Bureau of Publications, Teachers College, Columbia University, New York.

3 The term "principle" is used in this study to designate a general truth in science toward which the work in science is directed.

4 Craig, Gerald S. "Certain Techniques Used in Developing a Course in Science for Horace Mann School." Contributions to Education, No. 276, 1927. Bureau of Publications, Teachers College, Columbia University, New York.

Gerald S. Craig gives a suggestive list of principles of science. There is need for an extended study to determine the large principles about which a professional course in science for teachers in elementary schools may be organized.

A professional course on the collegiate level will provide for the development of large themes in science in such a way that the students will be prepared for the program of work that will be required of them in teaching science in elementary schools. In addition, it will provide a background of subject matter which has educational values that extend well beyond the needs defined by the particular work for which the students are being trained.

The purpose of this investigation is to develop techniques for the selection and organization of content for a professional course in science for teachers in elementary schools. The techniques developed have been illustrated by the use of the scientific principle:

Living things survive because they are fitted[5] to conditions under which they live and in which their structures and ways of living enable them to attain adult life and to leave offspring.

This principle is too far-reaching in its significance to be understood fully as it stands. It may be analyzed into subordinate principles or purposes which may be analyzed further into constituent parts that give it more specific meaning and that seem significant and appropriate for a professional course in science.

The field suggested by such an analysis is so broad that in selecting content it seems necessary to differentiate between the elements derived. Some elements are directly related to the work which the prospective teacher will undertake and also directly related to the development of the principle of science. Some elements are less directly related to the work of the teacher in training, but contribute to an enriched background of experience enabling the student to secure enlarged interpretations of the guiding principle toward which the work is directed. These differentiated elements have been designated in this study as core material and marginal material. Elements of core and marginal material were secured by analysis of three types of printed material:

5 "Fitted" in this connection implies that living things are sufficiently adapted to their environmental conditions to attain adult life and to leave progeny.

1. Thirteen books written by twenty-six authorities in their respective fields were analyzed. The books were selected on the basis of recognition which the authors had received in the field of science. Illustrations of books analyzed are:

   Gager, C. Stuart. *General Botany.* P. Blakiston's Sons and Company, Philadelphia, 1926. 1055 p.

   Holmes, Samuel J. *General Biology.* Harcourt, Brace and Company, New York, 1926. 449 p.

   Lull, Richard S. *Organic Evolution.* The Macmillan Company, New York, 1927. 729 p.

   Shull, Aaron F. *Principles of Animal Biology.* McGraw-Hill Book Company, New York, 1920. 441 p.

2. Twelve outlines of science in use in elementary schools in various parts of the United States were analyzed. Eight of these outlines had received the rating "good" by the Bureau of Curriculum Research, Teachers College, Columbia University. Four of the outlines were in use in progressive school systems in the country, but had not been rated by the Bureau of Curriculum Research at the time the study was made.

3. Literature written by recognized authorities in the various fields of science for the lay reader was analyzed. Illustrations of books used are:

   Compton's Pictured Encyclopedia. F. E. Compton and Company, Chicago, 1928. 10 volumes. 4423 p.

   Thompson, J. Arthur. *The Outline of Science.* G. P. Putnam's Sons, New York, 1922. 4 volumes. 1220 p.

   Carpenter, George H. *The Biology of Insects.* The Macmillan Company, New York, 1928. 473 p.

Core material was derived by analysis of the thirteen books written by authorities and by analysis of the outlines of science. Analysis of outlines of science gives the elements which, through experience and judgment, educators have considered suitable for pupils on the elementary school level. Analysis of literature gives, in addition to the elements included in elementary school programs, those elements which experienced authorities consider significant to the development of the particular principle of science under consideration, and which at the same time indicates the trends in modern scientific thinking. The books for the lay reader were used only as guides

in the selection of marginal material. Elements of suggestive core and marginal material were recorded on cards similar to the specimen filing card following.

Elements of Science Examined																
Seeds of plants are distributed in various ways.	Holmes	Burlingame	Woodruff	Shull	Pearse	Curtis and Guthrie	Curtis, C.C.	Gager	Sinnott	Holman and Robbins	Newman	Lull	Newman and others		
					291-292		127-128	430	201	242	242		228		
	Denver	Cleveland	St. Louis	Horace Mann	Berkeley	Francis Parker	Springfield	Oak Park		Long Beach	Toledo	Normal	Portland		
	27 41 60 82 85	1:4 2:4 3:4 4:7	82 120 209	3:35	35 44	23	41 55	3		86	32	66 105	9		

SPECIMEN FILING CARD

This particular illustration shows that seed dispersal is emphasized by seven of the books and by each of the twelve outlines of science. A study of the 1500 elements recorded on similar cards indicated that they were not all of equal importance in the development of the principle of science selected for the study. An element was included as suggested core material if it satisfied one of the criteria following:

1. If it is included in three of the eight outlines of science rated and in seven of the thirteen books written by experienced authorities in the fields of science relating to the selected principle of science.
2. If it is included in ten of the twelve outlines of science even though it is not included in the thirteen books written by experienced authorities.
3. If it included in at least one of the eight outlines of science rated, and in eight or more of the thirteen books.

4. If it is included in two of the four outlines of science not dated, and in eight of the thirteen books.
5. If it is included in ten books written by experienced authorities and can be analyzed into constituent parts which point toward an understanding of the principle of science, and if, by analysis, it seems suitable for core material.
6. If it is included in books written by experienced authorities or in outlines of science and does not meet one of the above criteria, but by analysis seems necessary to an understanding of the principle of science and appropriate for core content.

The elements selected as suggested core content by these criteria were organized in outline form. The main headings of the outline are as follows:

1. There are limiting factors in the environment of living things.
2. The environment of living things changes continually.
3. Living things respond to stimuli in their environment.
4. Living things have structures, functions, and habits which enable them to attain adult life and to leave offspring.
5. A balance in nature is maintained through inter-relations of plants and animals with living things and with their physical environment.
6. Through long ages there has been persistence of life upon the earth.

This outline of suggested core material was further refined by means of critical study by ten advanced students in the Science Seminar, Teachers College, Columbia University, and by ten experienced teachers who at the time the study was made were actually engaged in teaching courses in science to students training to teach in elementary schools.

The technique followed in analyzing literature for suggested core content was used in analyzing literature written for the lay reader. The elements included as suggested marginal material thus derived met one of the criteria following:

1. Those elements which, in the beginning, were included in the suggested core content but which were eliminated later by critical evaluation by experienced teachers and also by further analysis and synthesis of materials into teaching units.
2. Those elements which the thirteen experienced authorities considered important and which were not included as suggested core content, but which through analysis seem significant to an enlarged understanding of the principle.
3. Those elements selected by analysis of the books written by specialists for lay readers which seem significant in giving an enlarged understanding of the principle.

The marginal material selected by these criteria was studied critically by experienced teachers in science.

An idea of the results of this analytical study may be secured by the reproduction of a small part of the outline:

I. There are limiting factors in the environment of living things.

A. Light

Core Material

1. Light is necessary for life of plants and animals.
   a. The process of photosynthesis takes place in nature only in the presence of light.
   b. Light is a factor influencing the position of plant organs.
   c. Light intensity is a factor affecting the character of plant growth: Different species of plants are tolerant of different light intensities.

(There are additional topics of core material.)

Marginal Material

1. Light is a manifestation of energy.
2. All energy used by living things in carrying on their life activities comes directly or indirectly from the sun.
3. White light is composed of many colors.

4. Chlorophyll, like other substances, absorbs only certain rays from white light.

(There are additional topics of marginal material.)

B. Water

Core Material

1. Water is necessary for plant and animal life.
2. The amount of available water affects plant and animal growth.

(There are additional topics of core material.)

Marginal Material

1. The usual rate of metabolism slows down with drying of an organism.
2. The amount of water required by living things varies with the species.

(There are additional topics of marginal material.)

C. Temperature.

Core Material

1. Living things make various responses to environmental temperature changes.

(There are additional topics of core material.)

Marginal Material

1. Metabolism of most living things is affected more or less directly by temperature changes.

(There are additional topics of marginal material.)

The outline of additional limiting factors—air, soil, food and shelter, plants and animals, and gravity—follows the same general pattern as indicated by the portion of the outline given. The complete outline follows a similar treatment for each of the six main headings. The analysis used in this study in selecting core and marginal material is not exhaustive but it is extensive. It was carried to the point where further analysis yielded few new elements.

The technique which has been briefly described in this report and which has been illustrated by use of a principle of science gave a body of material which included the elements of content to be used directly by the pupils in the

elementary school. In addition it gave a body of elements which, when synthesized into a teaching unit, provided a comprehensive understanding of the principle of science, the goal toward which the work was directed. Furthermore, it defined for the prospective teacher a background of knowledge which is important for effective teaching.

An extension of this study which can only be mentioned in this report includes:

1. The organization of elements into a teaching unit in such a way that as teaching progresses, the simple elements will form more and more complex associations that will gradually develop an understanding of the principle in the minds of the learners.[6]
2. The teaching of the unit in a teachers' college to a class of prospective teachers under the observation of an instructor of wide training and broad experience in training science teachers.
3. An analysis of practices in teacher-training institutions showing need for some means of guidance in the selection of content for a course in science for teachers.
4. A study of the background of information in natural science for teachers in elementary schools.

The techniques developed in this study as a means of selecting and organizing content for a professional course in science for teachers in elementary schools may be summarized as follows:

1. The organization of teaching materials around large principles of science which may serve as guides in the selection of content.
2. The derivation of elements of core and marginal content by analysis of literature written by experts for the specialist and for the lay reader, together with analysis of outlines of science in use in elementary schools.
3. The selection, by means of criteria, of core materials which consist of those elements which relate directly to the principles of science and without which their suitable realization would not be attained.

---

6 Powers, S. R. "Research in Science Teaching." Teachers College Record. 30:334-343. Jan., 1929.

4. The selection, by means of criteria, of marginal materials which contribute to an enriched background of experience enabling the teacher in training to secure enlarged interpretations of core material and at the same time give him that security in his subsequent teaching which comes only through adequate training.
5. The evaluation of elements of core and marginal materials on the basis of experience and judgment of instructors who have had broad training in science and who are interested primarily in training teachers in elementary schools.
6. The organization of elements into teaching units in such a way that, as the teaching progresses, the simple elements will form more and more complex associations that will gradually develop an understanding of the principle in the minds of the learners.

NEW YORK STATE SCIENCE TEACHERS' MEETING

The New York State Science Teachers Association met in Syracuse on December 29 and 30 last.

Among other business the association passed unanimously a resolution, stating that it believes that the requirements for a College Entrance Diploma and for free State Scholarships should be so revised as to put a student specializing in the sciences on a par with a student specializing in the languages.

This makes the second year in succession that this association has expressed itself in this way.

The association also voted to continue its Teacher Placement Committee. All science teachers desiring positions in New York State and all school officials desiring teachers are asked to communicate their desires to Mr. B. J. Abbey, Niagara Falls High School, Niagara Falls, New York.

L. E. LATHAM, Retiring Secretary.

Science needs an international language, but neither Latin, Esperanto, nor any of the four great modern European languages would serve the purpose so well as Spanish, in the opinion of Professor Joseph B. Pike, since 1903 head of the Latin department at the University of Minnesota. Professor Pike, in his book "Classical Studies and Sketches," just published by the University of Minnesota Press, recommends Spanish as the future international language of scientific men because of its comparative simplicity and its widespread use in the world today. Latin, he thinks, will continue to serve as a basis for scientific nomenclature, but for the expression of ideas a more flexible language is needed. The adoption of Spanish, Mr. Pike thinks, would be likely to cause less international jealousy than might be aroused by the favoring of English, French, German, or Italian; and this would be a further reason for its adoption as the common speech of scientists.

An Analysis of the College Entrance Examination Board Examinations in Elementary Chemistry for 1921 to 1928

JACOB W. BOORSTEIN
New York Testing Laboratories

The purpose of this study is to analyze the College Entrance Examinations Board examinations in elementary chemistry for the years 1921-1928, in order to determine, if possible, (a) whether, through a comparison with an analysis for 1911-1920[1], there are any observable trends in the choice of the subject matter of chemistry considered important by the evaminers, (b) what are the tendencies of those who have prepared the examinations to stress the different chemistry topics, as judged by the total percentage allowance to each topic over the entire period, (c) whether there is any tendency on the part of the examiners to introduce an element of correlation between the science and the everyday experience of the pupils.

The first part of the analysis was suggested to the investigator by the analysis of the C. E. E. B. examinations of 1911-1920, made by Dr. Henry L. Gerry. Dr. Gerry endeavored to "determine the portions of elementary chemistry which the examiners seem to have considered most important, or at least to have asked most frequently." It occurred to the investigator that a similar study of examinations given in the years since Gerry's work was completed should show whether or not the examiners evinced any tendency towards change in the content of the examinations, and, if there were changes, what trends were discernable. Hence an analysis of the examinations given in 1921-1928 inclusive was undertaken. The procedure used was the same set up by Gerry and is described below.

As the investigator proceded with the analysis following Gerry's set up, it became apparent that a determination of "the relative value of the different topics in the minds of the examiners", would make an interesting and perhaps significant contribution. In order to determine "the relative value of the different topics in the minds of the examiners," another procedure was organized. The percentage allowance of each ques-

1 Gerry, Henry L., "College Entrance Examination Board Questions in Chemistry," School Science and Mathematics, XX: 845-850 (December, 1920).

tion was distributed among the different phases of the subject that it included. In addition, for greater clarity and for the sake of the relationships and contrasts that might become apparent, each of the eight main topics was in turn analyzed. The details of this procedure will be given later.

The examinations were viewed from yet another angle. The Board in the Introductory Statement of the Definition of Requirements suggests "It should be the aim of the teacher to emphasize, as opportunity offers, the essential importance of chemistry to modern life, and to the industrial and economic growth of our civilization." An attempt was made to determine to what extent the Board permitted or suggested an interpretation of the questions in terms of everyday experiences, as contrasted to questions that allowed purely scientific interpretations.

PROCEDURE

The examinations analyzed were those of June and September 1921-1928 inclusive, the comprehensive examinations of June 1921, and the extra examination of September 1926, eighteen in all. This was the number of examinations included in Gerry's analysis.

Finding that each examination was divided into two parts, (1), a "compulsory" part where every question must be answered, and (2), a "choice" part where the pupil is allowed a choice of three, four or five, out of five, six, nine and ten questions, the investigator made each analysis in three sections: (a) treating the compulsory section as a whole, (b) treating the choice section as a whole, and (c) treating all the questions together.

In the first analysis the procedure that Gerry set up for his study was followed. This was made possible by the possession in the hands of the investigator of Dr. Gerry's original data, supplemented by a letter from him with some very helpful notes on his method of analysis.

The items of Gerry's table of "All topics" were listed, and each time one occurred in a question, or subdivision of a question, a check was made opposite the item. The investigator made only the one departure of the separate summation of the compulsory and the choice questions in addition to taking all the questions together.

The second analysis was made in the attempt to determine the relative value of the different topics in the minds of those who prepared the examinations.

The assumption was made that the percentage of the total credits that were allotted to a topic or an aspect of the science over a period of years would be a criterion of stress on that topic or aspect. For the purpose of arriving at the percentage allowance, each question was split into its elements and the credit was divided as nearly as the investigator could determine the intention and purpose of the examiner.

This procedure has many subjective features, and, like the subjective grading of examination papers, is open to criticism. Yet it was felt that a closer measure of the stresses of the examiners could be arrived at through this means than by merely crecking items.

In this analysis Gerry's seventeen topics were cut down to eight, since it had been found that many items did not appear frequently enough to merit a separate listing. (No detail was lost however since each of the eight main classifications was in turn analyzed into its component parts).

The third part of the problem consisted of an analysis which attempted to determine the extent to which the Board offered opportunity for the interpretaion of questions in terms of everyday experiences.

The procedure was simply to classify each question, or part of a question, as either strictly scientific, a question on pure science, or one which by its wording might have had some bearing on the everyday life of the pupil. No weight was attached to the checks, so that a part of a question had the same effect on the final ratio as a whole question.

The questions chosen as being devoted to everyday experiences were further analyzed for a knowledge of the division of these items among the different topics, and for some idea of the relative frequency of occurrence of these topics.

Findings

1. When Gerry's procedure was followed it was found that "Salts, Oxids and Hydroxids' with 17.1% of the entire examinations, and "Equations' 'with 13.6% were the two most frequently appearing topics. The others in order of frequency

were "Laws and Theories"—8.5%, "Common Metals"—7.2%, "Common Acids" and "Laboratory Identification"—6.9% each, and "Gases not Elements"—6.6%.

2. The analysis conducted with Gerry's procedure gives a basis for the comparison of examinations of the two periods, 1911-1920 and 1921-1928. Increases were observed in the frequency of some topics and decreases in others. The following are the topics that, in the examinations of the later period (this investigation), showed an increased frequency: "Common Metals" from 3.6% to 7.6%, "Salts, Oxids and Hydroxids" from 13.8% to 17.1%, and "Laws and Theories" from 5.9% to 8.5.% Decreases were noted principally in "Common non-metals" from 8.4% to 7.2%, "Common Acids" from 8.7% to 6.9% and "Laboratory Identifications" from 10.0% to 6.9%.

As can be observed from the figures above, no very startling change has occurred. On the contrary, the lack of change is quite remarkable. It may well be that the parallelism of the findings of the two studies is condemnatory of the examinations. The largest gain in any topic is 4.0% (Common Metals); the largest loss is 3.4% (Laboratory Identification). Within the compass of these small changes no emphasized trend is apparent. The gain in frequency of "Common Metals" might be taken to indicate a trend in the direction of stressing everyday experiences. Gerry in his findings emphasized the low frequency of occurrence of questions on the "Common Metals". However, this, even with the largest noted gain, is only 7.6% of the total —not a very important factor and not a very great change.

3. No very marked difference in the make up of the compulsory and the choice sections was apparent when the analysis was conducted with Gerry's set up. The relative frequency of most of the topics was the same, or nearly the same in both groups of questions. The only outstanding exceptions were (1) "Equations," 20.3% of compulsory items and 8.6% of the the choice, (2) "Laboratory Identification," 4.8% of the compulsory and 8.4% of the choice. This does serve to mark the importance of "Equations," which was by far the most frequently appearing topic in the questions where no choice was allowed. Table I gives the values obtained. The fourth column, Gerry's Findings, was inserted to facilitate comparison.

TABLE I. *Percentage Analysis of Examinations for 1921 to*

1928 Compared with Gerry's Findings

	Compulsory Section	Choice Section	Entire Examination	Gerry's Findings
Common Non-metallic Elements	6.5	7.8	7.2	8.4
Common Metals	7.6	7.6	7.6	3.6
Common Acids	7.8	6.3	6.9	8.7
Salts, Oxids, Hydroxids	16.8	17.2	17.1	13.8
Gases (not elements)	6.3	6.8	6.6	6.9
Organic Substances	1.3	3.5	2.6	2.5
Identification Laboratory	4.8	8.4	6.9	10.0
Quantitative Experiments	.6	.3	.4	.6
Equations	20.3	8.6	13.6	14.5
Reversible Reactions	.4	1.8	1.2	1.4
Laws and Theories	9.0	8.0	8.5	5.9
Electrolytic Dissociation Theory	3.2	3.9	3.6	3.9
Chemical Arithmetic:				
a. Percent Composition	.9	.7	.8	1.8
b. Weights of Substances	3.3	2.4	2.8	1.7
c. Volume of Gases Reacting	3.0	1.7	2.2	3.1
Energy Changes	.4	.4	.4	.7
Oxidation and Reduction	.9	1.1	1.0	1.7
Solutions	1.4	2.8	2.1	2.1
Others	5.6	10.7	8.5	8.7

4. With the "Percentage Allowance" system of analysis which was described under procedure, a somewhat different picture was obtained. The difference in the make up of the compulsory and choice sections was very marked. In the former section "Equations" received 20.5% of the total allotted credits, "Problems" received 18.8%, "Laws and Theories" 16.5% and "Miscellaneous" 13.4%. In the choice section, "Miscellaneous" received 30.4% of the credits allowed to all the choice questions, "Problems" 13.1% and "Elements" 11.6%. "Equations" represented only 4.7% of the choice credits. When both sections of the examinations were taken together, the order of importance was varied a bit: "Miscellaneous" 23.7%, "Laws and Theories" 19.4%, "Problems" 15.4%, "Equations" 11.1% and "Elements" 10.9%.

The very great stress laid on "Equations" in the compulsory section and on "Miscellaneous" items in the choice section are the notable features. It is also significant that "Equations," "Laws and Theories' 'and "Problems" are allowed 55.8% of the credits in the compulsory section, 39.2% in the choice section, and 45.9% of the total examination. The decrease for the choice section is due to the omission of stress on "Equations." The above data in tabulated form is found in Table II.

TABLE II. *Percentage of Questions in Examinations from 1921 to 1928 Relating to Various Aspects of Chemistry*

	Compulsory Section	Choice Section	Entire Examination
Elements	9.9	11.8	10.9
Acids and Bases	7.6	6.9	7.2
Salts and Oxids	6.4	9.8	8.4
Gases (not elements)	6.9	1.9	3.9
Equations	20.5	4.7	11.1
Laws and Theories	16.5	21.4	19.4
Problems	18.8	13.1	15.4
Miscellaneous	13.4	30.4	23.7

5. The importance of "Problems," not observable in the previous analysis, is brought to light with the percentage allowance system of rating topics. "Problems" occur with a frequency of only 5.8% of the items in this investigation, (6.6% in Gerry's analysis), while the credit allowance given to "Problems" is 15.4% of the entire examination.

6. (1) Among the "Elements," Chlorine received the greatest stress, with Sulfur, Zinc and Aluminum next in order. (2) Nitric and Sulfuric acids and Ammonia were stressed to the apparent neglect of Hydrochloric Acid. (3) The spread of credit allowed among the salts and oxids was rather large and many unusual salts were included. (4) Only four non-elementary gases received any considerable stress, namely, carbon dioxide, carbon monoxide, nitrogen oxids and hydrogen sulfide.

7. Though there was still an annual occurrence of a series of equations to be completed or balanced, the specific equations required show some change from the conditions found by Gerry. Of ninety equations that were specifically called for, those resulting in the production of barium sulfate appeared four times, copper with nitric acid five times, copper with sulfuric once, and heating concentrated nitric acid not at all. Gerry found barium sulfate five times, copper with nitric acid three times, copper with hot concentrated sulfuric twice and the decomposition of heating concentrated nitric twice. A tendency was noted to ask for equations, the right hand members of which would interact, as carbonic or sulfurous acid with another acid, or an ammonia salt and a base. There were in all twelve such equations. There occurred four equations giving silver chloride. and several were based on the substitution of elements higher

Several equations made use of nitric acid as an oxidizing agent, in the electromotive series.

The ninety equations that were specifically called for were distributed in the five major classifications of chemical reactions with 58% of them "Double Decompositions" and 25% "Oxidation-Reductions."

8. The stress that Gerry found on the "Theory of Electrolytic Dissociation," was found also in this study. It was by far the most important item of theoretical content tested. This topic comprised 27.7% of the "Laws and Theories" in the compulsory questions, 21.5% in the choice and 23.9% together. Next in importance on the basis of percentage awarded, are the "Atomic Theory" with 8.1% and the Periodic System with 8.8%. These three take 40.8% of the credit allowed to "Laws and Theories." Boyle's and Charles' laws do not find any significant place in these tests.

9. "Problems appeared on every paper, and on only one examination were there less than two. The importance attached to chemical calculations was stressed by Gerry. The present investigator found that "Problems" was one of the two most constant and most important constitutents of the examinations. Analysis of the problems for types showed that most (87% awarded credit) of the problems in the compulsory section and about half (49.6% awarded credit) of those in the choice, were based on chemical reactions. These were in turn divided among:

(a) Given a weight to find a weight.
(b) Given a weight to find a volume.
(c) Given a volume to find a weight.
(d) Given a volume to find a volume.

The first of these four is the most frequently met. Problems based on Boyle's and Charles' laws, the dropping off of which was noted by Gerry, have almost ceased to appear—(1.3%).

10. There were a large number of topics classified as "Miscellaneous," appearing regularly on the examinations and usually forming a large portion of the choice questions. "Chemical Terminology and Nomenclature" is stressed greatly in the compulsory section, 26.6%, as are also questions on the "Nature and Composition of the Atmosphere"—19.3%.

11. The greater number of test items concerning "Elements," "Acids and Bases", "Salts and Oxids", and "Gases not Elements" were divided among five types calling for either (a) preparation, (b) properties, (c) recognition or identification, (d) laboratory identification, or (e) laboratory preparation. The most important, as measured by percentage of credit allotment, is in all cases, "Properties, Occurrences and Uses", which is credited with from 40 to 60% of the total allowances of the different topics. "Laboratory Preparation" usually received greater stress in the compulsory questions and "Laboratory Identification" in the choice questions.

The question on "Laws and Theories" seldom asked for a statement of the law, theory, or hypothesis. Instead, what was usually desired, was either an explanation or application which entailed understanding of the functioning of the theoretical matter.

12. It was found that a considerable stress was laid on typing up of chemistry with everyday experiences. A little more than one fourth (27.2%) of the number of items in the compulsory questions, a little more than one half (52.3%) of the choice questions, and something less than one half (43.6%) of the full examinations were questions or parts of questions that were felt to have some bearing on the daily life of the pupil. The most frequent item of the above nature, called for—"a practical use for—", "an industrial use for—", "give a property and use based on it—". This group constitutes 22.7% of the "practical" items. Questions based on "Lime, Limestone and Plaster of Paris", "Fuels", "Air and the Atmosphere", "Chemical names for Common Substances", "Water-hard waters", "Baking Powder and Baking Soda", "Fertilizers" etc., appeared with a considerable regularity.

13. Crawford[2] says, "It is better to contrast two periods that are separated in time than two that are adjacent in time." The truth of the statement is almost axiomatic, and so this investigator originally intended breaking up the series of eighteen examinations, in any manner that would most clearly show a change, if any could be perceived. In order to be in a position to do this, each examination was totaled separately. It was apparent at a glance at the totals that no break, sharp or gradual, was observable. Hence the entire eighteen examinations were treated as a whole because of the value of dealing

with a larger sampling, and because Gerry had also taken eighteen examinations. Since "apparent at a glance" is too subjective a way of judging, the totals for the first eleven, and the last seven examinations, were made and listed side by side with the totals for all the eighteen examinations and Gerry's results for his eighteen. These totals show that there was no gradual change in the frequencies that became obliterated when all the eighteen examinations were taken together and that nothing would have been gained by covering a smaller period further removed from Gerry's period. The frequencies for the eleven, the seven and all eighteen examinations, are very close in almost every instance. There are only three cases in which the variation is much more than 1%: 'Salts, Oxids and Hydroxids", "Equations", and "Electrolytic Dissociation Theory." It is very significant to note that in each of these cases the values for the later period were closer to Gerry's values, than the values for the earlier period. That is, "Salts, Oxids and Hydroxids" have a frequency of 19.0% for the eleven examinations nearest Gerry's period, and 13.2% for the seven examinations further removed, (Gerry's result is 13.8%). The other maintain the same average over a number of years as opposed to two are similar. This might be taken to indicate a tendency to a tendency to change.

Significance of the Findings.

There are several occasions in which the findings noted in this study should prove significant and helpful.

1. The curriculum maker, course of study builder, the prospective author of a chemistry text, concerned with preparing all or part of his pupils for the college entrance examinations should have at hand such an analysis of previous examinations to guide him in his construction.

2. Even where the pupils are not being prepared for the examinations, the findings should be consulted before an elementary chemistry text is written or a course organized, since this analysis represents the opinion of a group of men who are among the foremost in the field.

3. These findings should supply to the teacher of chemistry,

2 Crawford, Charles C., "The Technique of Research in Education," pages 58-59.

whether or not he is concerned with preparation for these examinations some very definite suggestions as to the placing of emphasis on the various phases of the subject matter.

4. Dr. Gerry and other educators who have prepared examinations for the different secondary school subjects have found it advisable to analyze the College Entrance Board examinations (among others) for suggestions of material to include.

5. The examiners themselves may not have had presented to them such a view of their test material. Though these examinations undoubtedly conform to the "Requirements" as set forth by the Board, it is a question whether the members are aware of the emphasis they are placing on the different topics. This analysis, showing as it does the tendencies they have displayed in the recent past, may suggest to them certain changes the need for which may not otherwise have been apparent.

6. Finally, this study may suggest at some later date, 1936 or 1940, a similar analysis to determine whether the same elements of elementary chemistry are being included in the College Entrance examinations, whether the emphases are the same, whether the new topics are being introduced into the test material or whether emphasis is being shifted. If such an analysis as detailed as the present one, is then undertaken, the present study will be a substantial basis for comparison, and trends, changes or the absence of changes will become apparent.

To the present investigator, changing the syllabus, the "Definition of Requirements", is not sufficient indication that the examinations are being changed.

What Constitutes a Desirable Program of Studies in Science Education for Teachers of Science in the Elementary School?*

E. Laurence Palmer

Professor of Rural Education, Cornell University

Any satisfactory answer to the question stated in the title of this paper will obviously have to take into consideration a number of conditions. Among the introductory questions to be answered would be some of the following:

What, if any, unique professional demands are likely to come to teachers of science in elementary schools?

What, if any, differences exist in the type of useful content in the field of science needed by elementary school science teachers and teachers of science at other levels?

Does preparation for science teaching at these grade levels require the same proportion of preparation in the field of content as does preparation in other fields of endeavor?

Are science teachers more liable to find the unspecialized teachers with whom they work less prepared to do successful work in science than are special teachers in other fields?

What are the usual time allotments given to majors and minors in other departments than science in Teacher-Training Institutions offering a three or four-year curriculum?

I propose answering these questions in the reverse order and so far as possible will refrain from expressions of opinion and base my conclusions on published or unpublished data collected from a sufficiently wide-range group of institutions and individuals to warrant their recognition as being valuable in the drawing of conclusions.

It is only just to say that it has been possible to collect much of this data because of support received in the form of graduate fellowships at Cornell University from the Charles Lathrop Pack Forestry Trust.

What Are the Usual Time Allotments Given to Majors and Minors in Teacher Training Institutions Offering a Four-Year Curriculum?

* Presented at the dedication of the Education Building, New York University, Science Education Conference, March 1, 1930.

This can probably best be answered by an article, "Status of Science Instruction for the Preparation of Elementary Teachers in Four-Year Curricula in Teachers Colleges and Normal Schools," by Fred T. Ullrich of Platteville Wisconsin Teachers College. It covers a survey of 131 catalogues of Teachers Colleges and Normal Schools. Fifty-six of these institutions offer four-year curricula for teachers preparing to work in the elementary field and in 39 of these students may major or minor in science. Professor Ullrich states that a typical major is from 24 to 40 hours and a typical minor about 20 hours. I hope to show that the maximum in each of these divisions is desirable in the preparation of special science teachers for work in elementary schools. It is not possible here to go into further details on Professor Ullrich's work but to point out that he presents data as it applies to the preparation specifically of kindergarten-primary teachers, intermediate grade teachers, elementary teachers, and upper grade and junior high school teachers. His figures apply not to special teachers but to general teachers and it therefore seems perfectly reasonable to recommend that the special science teachers meet at least the maximum requirements set for majors and minors for general teachers.

Are Science Teachers More Likely to Find the Unspecialized Teachers with Whom They Work Less Prepared to Do Successful Work in Science Than Are Special Teachers in Other Fields?

It would seem that the most satisfactory way to answer this would be through a survey of what teachers themselves feel in the matter and also of what teachers of teachers have to say on the issue. An uncompleted master's thesis by Ralph Edeburn gives some slight suggestion of what his final results will show. Returns from 1600 rural New York State teachers indicate that in their own judgment they have had less preparation to teach science than to teach geography, arithmetic, reading, spelling or language and about the same amount of training to teach science as to teach music, drawing or physical training. There are no elementary school subjects in which they state that they have had less preparation than they have had to teach science.

A similar study by the same worker of returns from fifty

widely-spread teacher training institutions indicate that, in the judgment of the teachers of science, general kindergarten teachers have less preparation to teach science than to teach music, drawing, reading, language or physical training and about the same preparation in science as in arithmetic or geography. In the judgment of the same individuals, the same generalizations apply to primary teachers. The intermediate grade teachers apparently have less preparation in science than in reading or language and approximately the same as in music, drawing, geography, arithmetic or physical training according to this same survey.

It might seem safe to say then that from the judgment of teachers themselves and of those who prepare them in teacher training institutions the science training of the general teacher is, if anything, less than it is in most of the other subjects which have a place in the elementary school. This has some bearing on the preparation of special teachers of science in the elementary school in that were the general teacher well prepared it would seem that the special teacher would be less likely to be called upon for excessive coöperative effort. Since the general teacher does not seem to be well prepared we may have reason to require higher standards of the special teacher to the end that success for all may be assured. This is, of course, based on the assumption which may or may not be true that the task of the science teacher is such that unique training is unnecessary.

Does the Preparation for Science Teaching at These Grade Levels Require the Same Proportion of Preparation in the Field of Content as Does Preparation in Other Fields of Endeavor?

It would seem almost unnecessary to consider that this question could be answered in the positive when we remember that science work in the grades more than any other field of activity relies upon the use of the learners own senses and not upon outside authority. Even in the lowest grades we teach that Columbus discovered America and the authority back of such a statement obviously is outside the child's experience. A teacher of the social sciences or of the three R's works with content less liable to checking through exercise of the learner's senses than does the teacher of science. Accord-

ingly, it would seem that the science teacher must be prepared to meet a greater number of issues in which the learner may be as qualified to pass judgment as is the teacher. Furthermore the diversity of the field of science is a factor which must be reckoned with when planning the training of a science teacher. A child or group of children in a community may be interested in moths and butterflies, while another group in the same community may be interested in radio. To meet the situation arising from these diverse interests requires unusual breadth and some considerable depth of training. Any factor of the child's environment may stimulate interest in the child while this is possibly not so true when applied to certain other fields of learning.

What, if Any, Differences Exist in the Type of Useful Content in the Field of Science Needed by Elementary School Science Teachers and Teachers of Science at Other Levels?

It would seem that upon the recognition of differences in this field a great deal depends. Teachers who find that their preparation in science is not suitable to the demands which they must meet may well be easily discouraged and do unsatisfactory work. Others may be discouraged from entering the field of science through the failure of others to succeed. At the meeting of the National Association for Research in Science Teaching held at Atlantic City in February, 1930, it was brought out by one speaker that many superior students did not register for science electives primarily because of the fact that the work in science was generally considered unpopular. The speaker feels that much of the science work in pre-college levels has been unsuitable primarily because it has to no inconsiderable degree been organized frequently for the purpose of preparing the student for research work or college.

There seems to be a tendency in some institutions to aim towards recognition and professional standing with higher institutions rather than aiming towards accomplishing the results for the achievement of which the schools are founded. Teacher training institutions are founded for the purpose of training teachers not for the purpose primarily of furthering scientific research. Accordingly the content offered students in these institutions should be such as will help the students

in teaching at the grade level of their choice rather than helping them master the technique of advanced research. I would be the last to say that research activities should be delayed until the graduate years are reached. Rather I should like to put research activities down to the very lowest grades but the technique with which a first-grade child will conduct his research will differ considerably from that to be followed by the graduate research fellow. To be sure they will have something in common but they will work with different kinds of problems, with different kinds of tools, and with different ability to observe accurately and to draw safe generalizations.

To make clear the content offered in a subject for use by science teachers in a teacher training institution as against that suitable for offering in a course to students who may not go into this field, let me offer the following suggested differences.

MAMMAL STUDY

Content and Method Suitable for Emphasis in a Teacher-Training Institution.	*Content and Method Suitable for Emphasis in Research Institution but Unsuitable in Teacher-Training Institution.*
Recognition of species native to territory served.	Recognition of exotic species.
General information on home life.	Detailed studies concerning the mechanics of reproduction; embryology.
Types of locomotion, food getting, means of protection, aestivation and hibernation, general habits and behavior.	Detailed anatomical studies, detailed studies in physiology, detailed nutrition studies.
Studies in simple relationships.	Deep studies in genetics.
Distribution and migration of local species, track studies.	Distribution and migration of exotic species, considerable study of fossil forms.
Studies of literature suitable for use by children to be taught, including recognition of such characters as Raggylug, Krag, Stickeen, Red Fox and others.	Considerable studies in the literature based upon pure research and dealing with small groups exhaustively.

Care of pets, including feeding, housing and rearing.	Considerable experimental work with living animals capable of resulting in injury or death to them; "the anatomy of the cat."
Studies on where to find local species in natural haunts.	Exhaustive studies on ecology of little known species not likely to be subject to observation of group served.
Techniques and skills in connection with keeping of records on maps, calendars, in plaster, blue print and photographs.	Techniques and skills involving considerable use of compound microscopes and dealing with use of excessively accurate instruments of measurement.
Techniques involving the use as teaching devices of visual instruction equipment of a simple nature.	Techniques involving use of highly expensive and complicated teaching devices which the teacher cannot hope to employ but may think necessary for satisfactory teaching.
History of relative abundance and nature of local species in past, present and possibly in the future.	Detailed studies in vertebrate paleontology.
Biographies of persons who have written about the members of group studied for children to be taught.	Considerable studies of biographies of persons justly famous only for research in the field.

This list could be elaborated almost indefinitely but it would seem that sufficient has been given to emphasize the point in question. It should be pointed out, however, that practice in working with real things in natural settings should not be sacrificed for the purpose of acquiring knowledges, skills and attitudes useful primarily in furthering the acquisition of knowledge for the human race in general. Those being taught are to teach children and this should be kept constantly in mind. This will require education of teachers of science in teacher training institutions to no small degree since many have had their special training in research institutions and secretly or openly think of their connection with the teacher training institution as a stepping stone towards a research position in pure science in a great university. Unless these

individuals honestly recognize the function of the institution with which they are connected and try to perform that function they may do a great deal of unsatisfactory work. Departments of science in universities should recognize that a goodly number of their students are going into teaching positions at the pre-college levels and should offer courses suited to the needs of these graduates. Only today, I have received a letter from a professor of elementary education in a great mid-west university deploring the fact that he cannot get the science departments of his institution to offer courses which will be of use to his students who will be training elemenfary school teachers. This situation must be met before any real progress can be made.

What if any Unique Professional Demands Are Likely to Come to Teachers of Science in Elementary Schools?

Since it seems evident that the teacher of science may need an unusual breadth of training it may be safe to assume that he or she may very well find a usefulness over a greater range of grade levels than would otherwise be the case. This would be particularly true in the smaller communities with which my personal interests are closely identified.

If it could be shown that the special science teacher in the elementary schools would immediately enter upon a program as universally adopted as some of the other studies, the problem would be different. But it seems at present that there is considerable evidence that the special science teacher will work with more than one grade or with more than one group of grades. We need not expect that we will have immediately an overwhelming demand for special science teachers for the second grade. Rather we shall have, as we do, a demand for science teachers who are able to work in all of the first six, or eight, or ten grades. This situation again places a rather unusual demand upon the special teacher for professional training. The speaker feels, however, that a reasonable mastery of this situation can be made with the standard offerings along professional lines in most of the teacher training institutions. He would not favor the production of the type of teacher who said that she knew three ways to teach about Greenland but did not know where Greenland was.

In brief it would seem that the demands which the science teacher must meet should be kept in mind by the advisors, assuming first that the student has the basic content thoroughly mastered. One correspondent recently made the statement that those specializing in science education with him had science in their undergraduate work. This should not be sufficient. It should be shown that the science training is not just existent but adequate. The speaker once overheard an advisor counselling a prospective high school biology teacher. The candidate stated that she had had two years of biology in high school and one in a teacher training institution. On this basis the candidate was advised to take more professional work and no more work in biology though she had already had more hours of work in the professional field than in the field of science content. The speaker does not feel that such advice was sound. It would seem that at least one half of the time of a student could well be put on mastery of the content with which he will deal and the remaining part could be devoted to cultural subjects and to the necessary professional studies.

In selecting the professional studies it should be kept in mind that the special science teacher may be called upon to help teachers correlate science activities with other studies. To this end the science teacher should have some concept of the functions and general contribution to education of these other subjects. The student should also have some understanding of the functions, organization and activities of the junior and senior high schools particularly in the case of teachers who expect to work in small communities. The teacher could well be prepared to work with the teacher having charge of science in the upper levels or in the smaller communities might be responsible for the science work at all pre-college levels rather than teach some of the absurd subject combinations now expected to teachers in these schools.

Recommended Schedule for Special Science Teachers for the Elementary Schools Prepared to Take Four Years in Training.

In the subjects listed below it is intended that the nature of the content would be in accord with the recommendations previously made. As illustration of what this content might well be in the case of domestic mammals and star study, I may be

permitted to refer to some of the leaflets on this subject which it is my privilege to prepare for use in the rural schools of New York. These are used at all levels from the kindergarten to the senior high school, some of the material being suitable for use at one level and other at other levels. Students at Cornell University preparing to act as nature and science supervisors or as teachers of science in teacher training institutions make their initial approach to the various fields of science through content such as is illustrated by these leaflets. In addition, we offer a sufficient variety of suitable courses in the various science departments to provide the additional background of content and field experience. I mention Cornell because of the fact that I know the situation there better than elsewhere.

It would seem desirable that teacher training institutions should provide science courses which may be open to those not intending to become specialists and which will be valuable as introductory to those intending to specialize. To this end I recommend the offering of the following courses:

Nature Study or Elementary Science, 3 hours. A course essentially of professionalized content, not exhaustive but useful to the general teacher.

Agriculture or Gardening for Elementary Schools. 3 hours. A course designed to provide useful techniques in working with the tools man has used to make his environment produce valuable products for him.

General Ecology. 2 hours. It is recommended that this course be taken in the senior year, following other science work, and that it be broadly interpreted to include physical and biological science. Its function is to bring together the contributions of the specialized course following.

It is recommended that all taking majors or minors in science take the above 8 hours and, in addition, certain other courses. In accord with the findings of Ullrich previously stated it is recommended that a major constitute 40 hours of work and a minor 20 hours. It is recommended that special science teachers take a major in biological or physical science and a minor in the department not selected as a major.

The following minimum offerings for these two fields are made.

Biological Sciences. Majors taking 36 hours; minors, 16 hours.
Educational Biology ..... 6 hours

Zoology, Invertebrate ..... 6 hours
Vertebrate ..... 6 hours
Botany, General, including Plant Physiology..... 3 hours
General Systematic Botany ..... 6 hours

Human Biology:

Human Physiology ..... 3 hours
Health and Sanitation ..... 4 hours
Nutrition ..... 2 hours
Bacteriology ..... 2 hours

Physical Sciences. Majors take 36 hours; minors, 16 hours.
Physics, General ..... 6 hours
Applied (primarily for help in General Science).. 6 hours
Chemistry, General ..... 6 hours
Applied (for use in General Science)..... 4 hours

Earth Science:

Geology, including physiography, historic geology and mineralogy ..... 6 hours
Weather and Climate (Meteorology) ..... 4 hours
Commercial Geography ..... 3 hours
Astronomy ..... 3 hours

The above recommended schedule does not differ in the total number of hours recommended for minors and majors and considered as typical of a few institutions by Professor Ullrich in his study of 131 Teacher Training Institutions, published in the April issue of NATURE AND SCIENCE EDUCATION REVIEW. It departs from the offerings of these institutions as shown by his study primarily in strengthening the offerings in the field of physical science, particularly in chemistry. The speaker recommends strengthening in this direction without apology. If the speaker can judge of the offerings of these institutions from over 100 exhaustive questionnaires recently received from them, he feels that the teachers have sound ideals as to method and content. He hopes that ideal conditions may be more generally existent and that the follow-up investigations to be made during the spring months will show that the evidence submitted by the questionnaires is more reliable than that checked on a similar survey some three years ago. If the teachers of these institutions generally can be given assistance permitting a reasonable schedule it would seem that success is ahead.

The School Museum

May Weber Smith

Taylor Allerdice High School, Pittsburgh, Pa.

A school museum is a collection of objects of interest. It is also the place where these objects are kept. A museum should contain an abundance of definite, concrete things that provide an element of wonder, an æsthetic appeal, or a lure of interest. It is primarily educational, since it holds a collection of objects that can be seen and felt; and objects that can be seen and felt are to the child the realities of life. A child's understanding is woven from the strands of sense perception.

Associated with the objects themselves are their care, preservation, and interpretation. All materials should be well supplied with labels. In its beginning in the school, the museum may be a novelty, then it becomes a convenience, and later an actual necessity — an integral part of the educational scheme providing increasing and ever-widening interest. For the science teacher it is an invaluable aid in creating scientific interest. Lawrence Coleman, Secretary to the American Association of Museums, says that it is futile to attempt to teach geography, art, or nature without illustrative material. He could well have included all the other subjects in the curriculum, for interest generated by concrete material will enrich any subject. While teaching without concrete tools may not be exactly futile, the gain in the learning products through the aid of objective methods warrants their extensive use. Forced learning makes school irksome. Spontaneous learning is both profitable and pleasant. It is spontaneous learning that attaches itself to the things of the museum. Thorndike and Gates say "there is a great increment of motive power and zeal from the strong interest in the concrete and objective and in the manipulation of physical things."[1]

In this age of visual instruction the museum may be a valuable aid. A good educational program should make some provisions for its development. However, but little attempt has

1 Thorndike and Gates—"Elementary Principles of Education," Macmillan 1929—p. 124.

been made to establish school museums except in some large high schools.

A successful campaign for a school museum may be launched by a teacher in sympathy with the undertaking. The need for it can be established in the minds of the pupils by revealing its advantages. A science teacher is usually well fitted to supervise the museum program, though the contributions can be well utilized in other classes. The wide range of interests included in any science course of study reveals almost unlimited sources of museum material. Pupil investigations and reports, laboratory experiments, field trips, and other science activities suggest worthwhile contributions and the means of their acquisition. A museum fostered by the writer, but established and maintained by the students, furnishes material for science, art, geography, social sciences, literature, and construction, as needed, although established specifically for general science. In most instances, requests for exhibits to be used in other classes come from the pupil. He knows the museum content, and associates the objects or display with his class work.

The keenest interest obtains when the founding and maintenance of a museum devolves largely upon the pupil. It is important that a student be made to feel that he is an integral and necessary part of his school. To obtain a generous pupil response, there must be no insistence, only suggestion. After the initial interest is aroused, a deluge of offers from the pupils will follow.

Among the determining factors for the general tone and value of the articles contributed will be the teacher's influence and the environment, experience, and initiative of the pupils. A strong teacher will inculcate a love for the beautiful and true, and foster discrimination. His part in the program is that of wise leader and counselor.

Frequent opportunities for arousing interest in collecting for the museum will arise or may be created without number. A report on volcanoes, given by a junior high school boy and illustrated by drawings of his own, aroused the suggestion that material from a volcanic region might be worthwhile. The result was an excellent exhibit from Mt. Vesuvius brought in by a student who made a trip to Europe the following vacation.

Sustained interest, necessary to the vitality of the museum,

may be maintained in numerous ways. The care of the museum should be primarily a pupil activity conducted under unobtrusive supervision. From time to time the pupils change the aspect of the shelves, associating certain objects with others bearing some definite relationship. These relationships are legion, but a suggested few are, national, historical, scientific, periodical, and subjective. Arrangement, rather than quantity, will determine the usefulness and attractiveness of exhibits. Even if shelf space is abundant, as the scheme grows some collections will need to be transferred to labelled boxes or filing cases, to be displayed later as occasions arise. Timeliness of display stimulates interest, and maintains vital contact between museum and curriculum.

Loyal support may be tactfully enlisted by providing that all pupils play some part in collecting, labelling, preparing or arranging materials. This active participation fosters a sense of pupil ownership and responsibility toward the museum. This attitude will be reflected in their loving care of all objects and in their efforts to maintain worthy displays.

Pupils familiar with the exhibits delight in initiating new entrants into the mysteries and pleasures of the collections. Thus they enlist new recruits in the service of collecting, so that the museum is ever on the increase. Good judgment needs to be exercised lest too much may be accumulated. However, care must be exercised in discarding offerings. Often the most lowly contribution is rich in possibilities.

A real find came to the writer from a timid youngster, whose older brother was responsible for his shy visits to the science room. A covered glass containing a half-dead, woolly-bear caterpillar was hesitatingly handed in by the little fellow one morning, and for no reason whatsoever was left upon the desk, instead of being sent where half-dead, woolly-bear caterpillars ought to go. In a day or two, four big black flies were discovered in the glass. Upon close examination, the larva was found to have been the victim of a parasitic fly. The defunct caterpillar, the flies and their pupa cases, together with proper labelling, made a valuable mount.

Though but little has been done to provide museums for schools, there are several cities whose attempts to supply this particular kind of visual aid are worthy of note.

St. Louis maintains an educational museum for its public schools. This is a traveling museum, material being taken from one school to another as ordered. Pittsburgh has an arrangement with Carnegie Museum by which certain collections and mounts of the museum are loaned to the schools for a specified time. In addition to the municipal museum material, the Board of Education of Pittsburgh maintains an extensive department of visual aids that circulates, upon the request of the school, material that may be held for a limited period. Dr. John A. Hollinger, Director of Science, Pittsburgh, is directly responsible for this adequate visual department, and for its high standard of efficiency. Cleveland's Educational Museum has certain sets of pictures and some exhibits for loan to the city schools.

However, most schools will necessarily depend upon teacher and pupil efforts to build up such a collection. Any teacher undertaking the establishment of a museum must have enthusiasm and initiative to insure a successful venture. Dr. Mengel, a science teacher of the Boys' High School, Reading, Pennsylvania, was just such a teacher. The growth of the school museum started by Dr. Mengel culminated in an extensive educational museum available to all the city's high schools. This museum is now under the management of the Board of Education, and is cared for by a director and assistants.

The most valuable contributions will be made by the pupils. The combined opportunity of a general student group outweighs that of most teachers. School excursions and individual trips yield valuable material. A number of ancient fern tree fossils were collected on one short trip. These were used in botany, general science, art and geography. Outdoor excursions will furnish specimens of animal and plant life so numerous as to require most careful selection of the fittest, lest an overstock be made.

Educative exhibits prepared by various concerns may be obtained either gratis or at small cost. See your local industries. School exchange of collections may be profitably made between your school and that of another district, state or country. This is both feasible and worthwhile. A wide variety of companies offering good science material is listed in Fay Griffith's "Illustrative Material." "The Science Classroom" publishes an extensive and reliable list of firms offer-

ing such material. Both of these references include and indicate materials gratis or at small cost.

Some values to be derived from the museum are: (1) The museum is a potent agency for generating scientific interest and stimulating the learning process. (2) It provides a wide range of pupil activities that are rich in sense perceptions, thus contributing to understanding. (3) Meaningful material increases the ease of learning through the law of association. (4) The museum content supplies the concrete for intensity of impression, intensity being long recognized as a valuable aid in learning. (5) The pupil activities involved in its operation build for school loyalty and stability of purpose. (6) The many associations included in each object correlate the various subjects studied.

Probably no other school agency proves so potent a factor in coördinating the curriculum.

Mathematics and First Year Chemistry

B. CLIFFORD HENDRICKS
TEACHERS COLLEGE, UNIVERSITY OF NEBRASKA
LINCOLN, NEB.

In thumbing recent issues of three magazines for science teachers the writer finds no less than seven papers[1] in the last eight months which have to do with the mathematics of chemistry. It is questionable whether that much attention is proportionate to the subject's importance or even its actual stress in the first-year chemistry courses as they are offered. However, these papers indicate a teaching tension in that phase of chemistry. There is quite a general agreement that arithmetic does bother first-year students of chemistry. These papers may express the fact that the arithmetic troubles of the student of chemistry are becoming an annoyance to the teacher.

Webb and Boles say[1d] that the arithmetic of chemistry is mostly proportion; Pressey indicates[1e] that the arithmetic demanded, for college sciences in general, is multiplication, divi-

1-a. Earle R. Caley, Journal of Chem. Education, 6, 1979-1983 (Nov. 1929).
b. Paul K. Winter, Journal of Chem. Education, 7, 355-357 (Feb. 1930).
c. Luella C. Pressey, School Science and Math., 30, 238-243 (March, 1930).
d. Hanor Webb and Leo Boles, Science Educ., 14, 539-547 (March, 1930).
e. Horace G. Deming, Jour. of Chem. Education, 7, 591-593 (March, 1930).
f. Hoyt C. Graham and John A. Huff, School Science and Math., 30, 525-528 (May, 1930).
g. J. L. Rendahl, School Science and Math., 30, 683-689 (June, 1930).

sion, and addition of both integers and decimals; while Rendahl[1g] found the use of geometry negligible in chemistry and that algebra is used only in first-degree equations and for substitutions in formulas. He reports that one high school chemistry text avoids the use of proportion entirely and says, "It is not necessary to conclude that the process (proportion) is essential to the student of high school chemistry." Miss Helen Hald in a study of "Arithmetic and Algebra Processes as Sources of Student Difficulty in University Courses[2] from an examination of the scores made by 931 students on the Iowa Chemistry Aptitude Test reports a Pearson correlation of .45 between the mathematics part of the test and the student's grade in chemistry. She rates the order of dffiiculty for processes involved as: (1), (most difficult) proportion; (2) changing a common fraction to a decimal; (3) percentage, etc.

Webb and Boles[1d] say, "There is comparatively little mathematics presented in our present texts of general inorganic chemistry." The writer has yet to find a set of objectives for either high school or beginning college chemistry in which the arithmetic of chemistry is specifically mentioned. May it not be that the arithmetic of chemistry is merely a tool used to refine the thinking of students in the subject? If so, the *method* of problem solving should not get in the way of *chemical understanding*. The writer believes that there is no point to the use of time allotted to chemistry in learning new processes in arithmetic. Rendahl puts it: [1g]"The study of proportion is optional in many courses of study in arithmetic and many students are unfamiliar with it." The writer's experience with students in college chemistry is in accord with that statement.

Two worthwhile objectives for this work may be attempted which lead to more definite understandings of chemistry: first, a frank recognition that the vocabulary of arithmetic, which is needed in expressing chemical facts, needs refurbishing; second, that the process called proportion is nothing more nor less than a more generalized use of multiplication and division.

With respect to the first of these, Rendahl and Pressey have done a distinct service in listing the vocabulary. Pressey[1e] suggests a test on "concepts" which could aid the teacher to know the students' individual deficiencies in this regard. Here,

2 Unpublished Thesis (1930), University of Nebraska Library.

as in the use of new words needed in the development of his subject, the wise teacher will not neglect drill where it is needed.

Generalization comes after a consideration of many particulars. Surprising as it may seem, so large a portion of the members of classes in chemistry is not sure enough of the particular operations, multiplication and division, as applied to reality, that they are not ready for the more generalized process, proportion. In fact, the writer would venture that more than seventy-five per cent of the teachers of chemistry would not solve the following problem by proportion: "What will be the cost of five pounds of sugar which is advertised at sixteen pounds per dollar?"

Teaching, if successful, gets the learner to work out relationships between the new and his experience. Such mental activity is called thinking. Chemistry is new, and unless care is taken by the instructor all that is found associated with chemistry may be inferred by the student to be new. This applies to the arithmetic of chemistry as well as the vocabulary and the materials of the science. The point the writer seeks to make is, use care that the process suggested for use in problem solving is no different from that which is familiar to the student in his shopping activities.

A type of generalization demanded in other phases of chemistry applies likewise to the arithmetic of chemistry. That generalization is best labelled "process." Pupils must habitually group particulars into the correct process. Ultimately, not only does the teacher wish to get the pupil to think neutralization when he considers the combination of an acid and a base, but he should, quite as skillfully, think one pound of sugar will cost one sixteenth of one dollar and five pounds will cost five times that of one pound or five times one sixteenth of one dollar. He needs to be weaned from the idea that the answer is the all-important requirement and impressed with the importance of the *process* which will enable him to get hundreds of other answers.

The process involved in the problem used above should have been mastered in the sixth grade of the public schools. Unfortunately the *process* was not mastered. Perhaps the generalization required in mastering it as a process is too much to expect of a pupil of that grade level. However that may be, this process ought to be within the range of any student who studies

chemistry, whether in high school or college. And its application, assuming a working understanding of a rather simple arithmetic vocabulary, will do a surprising service in solving chemistry's "problem of problems."

Leaving out of consideration mass action problems or those involving solubility product, all others may be grouped under the seven captions: 1. Density. 2. Composition. 3. Gases. 4. Formulas. 5. Equations. 6. Concentration. 7. Energy.

A typical density problem may be: How many cubic centimeters of sulphuric acid with a density of 1.82 g. per c.c. are needed if a sample of 11.83 grams of solution is called for in the experiment?

The problem says:
1.82 g. of acid is one c.c.
then 1.00 g. of acid is 1/1.82 of 1 c.c.[3]
and 11.83 g. of acid are 11.83 × 1/1.82 c.c.

The reader should note the procedure is identical with that followed in finding the cost of five pounds of sugar when the price of sixteen was given.

A simple problem calling for composition might be:

When a sample of 1.59 grams of reduced copper is heated in a stream of oxygen until no further change in weight could be detected, the oxide weighed 1.99 g., what is the composition of the oxide produced?

The entire sample, 1.99 g. of oxide, is 100% of it,
then 1.00 g. of oxide is 1/1.99 of 100% of it,
and 1.59 g. of copper, in the oxide, is 1.59 × 100/1.99% of it,
and the oxygen (1.59 g. — 1.59 g.) .4 g. of the oxide =
.4 × 100/1.99% of it.

The writer feels that there is little warrant for as much of a time assignment to gas problems as is implied in many text books of chemistry. However, such problems yield to the same sixth-grade arithmetic as may be illustrated in the following: What weight would 380 c.c. of hydrogen have which is contained in an inverted flask over ice-cold mercury and held at a pressure of 72 cm., if one liter of hydrogen gas at 0° C. and 76 cm. weighs .0899 g.?

72 cm. of pressure permits 380 c.c. of volume
1 cm. of pressure would permit 72 × 380 c.c. of volume
76 cm. of pressure would permit 1/76 of 72 × 380 c.c. or 360 c.c.
1000 c.c. of this gas at 0°, 76 cm. weighs .0899 g.
1 c.c. of this gas at 0°, 76 cm. would weigh 1/1000 of .0899 g.
360 c.c. of this gas at 0°, 76 cm. would weigh 360 × .0899/1000 g.

---

3 Since only the process is of interest in this paper, results generally will not be given.

Assuming the definition: A formula weight of a gas is the weight of 22.4 liters of it at standard conditions, the following illustrates the use of the sixth grade process in the calculation of the formula of a gas:

The composition of a gas, whose density is .7708 g. per liter, is 82.4 per cent nitrogen and 17.6 per cent hydrogen. If the atomic weight of nitrogen is fourteen and hydrogen is one, what is the formula of this gas?

The problem says one liter weighs .7708 g.
Then a formula weight or 22.4 liters weigh $22.4 \times .7708$ g. $= 17.3$ g.
100% of the formula weight of this gas = 17.3 g.
1% of the formula weight of this gas = 1/100 of 17.3 g.
Nitrogen, 82.4% of the formula weight of this gas $= 82.4 \times 17.3$ g./100 $= 14.3$ g.
Hydrogen, 17.6% of the formula weight of this gas $= 17.6 \times 17.3$ g./100 $= 3.0$ g.
14 g. nitrogen = 1 gram atom
.1 g. nitrogen = 1/14 gram atom
14.3 g. nitrogen = $14.3 \times 1/14$ g. atom
1 g. hydrogen = 1 g. atom
3 g. hydrogen = 3×1 g. atom
Therefore the gas's formula is N_1H_3

Problems requiring the quantitative interpretation of equtions would be voted most unanimously, by chemistry teachers, as the most essential of all chemical arithmetic. The solution of such a problem may be:

How many liters of gas, for raising biscuits, may be obtained from a pound (453.6 g.) of baking soda by use of sour milk (i.e. lactic acid, $HC_3H_5O_3$)?

The equation when written is:

$$Na\ H\ CO_3 + HC_3H_5O_3 \rightarrow NaC_3H_5O_3 + H_2O + CO_2$$

Problem: 453.6 g. = (?) liters

The equation says: 84 g. of soda yields 22.4 liters of CO_2
1 g. will yield 1/84 of 22.4 liters
453.6 g. will yield $453.6 \times 22.4/84$ liters

A major element of difficulty in concentration problems is not the arithmetic but the vocabulary. These involve the distinction, not altogether too clear in minds of the best of students, between moles and gram equivalents and the proper use of the terms normal and molar in expressing this distinction for solutions. Vocabulary assumed, the problem: "How many cubic centimeters of fifth-normal sulfuric acid are necessary that it may contain 1.4 g. of the pure acid?" may be solved by:

2N acid contains 98 g. of sulphuric acid per liter of solution,
then 1N acid contains ½ of 98 g. of sulphuric acid per liter of solution,
and N/5 acid contains 1/5 of 98/2 g. of sulphuric acid per liter or 4.9 g.
So 4.9 g. of N/5 acid is contained in 1000 c.c.
1 g. of N/5 acid is contained in 1/4.9 of 1000 c.c.
1.4 g. of N/5 acid is contained in 1.4 × 1000/4.9 c.c.

Problems involving energy considerations have as one of their chief elements of difficulty, the demand that an equation assume a still larger burden of quantitative meaning. The most common types of such problems involve either the absorption or evolution of heat or electrical energy. The former is associated with molar quantities, the latter with equivalents. These of necessity require a working knowledge of a vocabulary including calories, amperes, coulombs and ion charge.

A problem of the first type is: How many grams of hydrogen should be burned to exactly melt ten grams of ice, each gram of which requires 80 calories of heat in melting?

First the equation $2H_2 + O_2 = 2H_2O + 136{,}716$ calories
Problem: ? g. required to give 10×80 calories
The equation says: 136,716 calories are produced by 4 g.
1 calorie would come from 1/136,716 of 4 g.
800 calories would require $800 \times 4/136{,}716$ g.

True, it is but one step from these solutions to setting up a proportion. The writer contends, however, that the process here used is a necessary forerunner of the proportion if that proportion is to be any better than a guessing exercise.

And then proportion is a big word and quite as mysterious as is catalysis, metathesis, electrolysis and a lot more of the chemistry "lingo" which the novice tries to make his own. While sixth grade arithmetic—well at least he has heard of it and he will hardly confess he can't do it. Just taking away the strangeness of the process helps.

Surely, as the student can graduate into the proportion method of problem solving he should be encouraged to do so. Always with proviso that he must justify his proportion—it may be by the sixth grade process. For the teacher of chemistry the writer feels that there is another proviso and that "never allow the mathematics get in the way of the chemistry. If one must go," he would say, "out with the mathematics."

Abstracts

GENERAL EDUCATION

Types and Fields of Curriculum Research in Secondary Education During 1929. H. R. Douglass. School Review XXXVIII: 656-662, November, 1930. Reports from two hundred professors and deans of departments of education, articles in the 1929 issues of eight educational periodicals, and a half dozen books and monographs dealing with curricular researches were used as sources to discover the 74 curriculum studies here summarized. The striking fact in this survey is that practically all studies were confined to the subjects as now organized in high schools and did not include the objectives in secondary education. In the field of science, chemistry receives greatest attention, four of the nine studies being given to chemistry. Most of the science studies were concerned with the objectives of the various subjects; none dealt with organization or grade placement of instructional materials.—C. J. P.

Recent Developments in German Secondary Education, II. H. H. Punke, School Review, XXXVIII, November, 1930. Teachers of science will be interested in the time allotted to science in the various types of secondary schools of Germany and will wish that science could be given as much time in our own secondary schools.—C. J. P.

SCIENCE EDUCATION IN GENERAL

The Cost of the High School Science Department. A. C. Monahan. School Science and Mathematics, XXX: 1025-1032, December 1930. Science teachers who have difficulty in securing necessary funds for furniture or equipment will find data in this article which will be useful in comparing the cost of instruction per pupil in science subjects and other high school courses. Table of data are given also indicating the approximate cost of apparatus and equipment for various sciences, also for industrial arts, home economics and other practical courses.—E. R. G.

A Science Auditorium Program. Carl F. Hanske. School Science and Mathematics, XXX· 884-893, November 1930. This paper discusses a program which can be given in forty minutes and involves the participation of twenty-five pupils. Two general rehearsals gave satisfactory presentation.—E. R. G.

A Study of Unfounded Beliefs Among High School Seniors. Gerhard E. Lundeed and Otis W. Caldwell. Journal of Educational Research, XXII: 257-273, November, 1930. The problem of this study was to find to what extent high school seniors and college students have heard of, believe in, and are influenced by certain types of unfounded beliefs. A questionnaire consisting of 200 items was sent to six rural high schools in Kansas, Indiana, Kentucky and Pennsylvania and four high schools in New York, Minneapolis and Chicago. Usable returns were filled out by 918 students (526 boys and 392 girls). Usable returns were received from 264 college students (108 men and 156 women) in the University of Illinois; Teachers College of Columbia University and New York University. Some of the findings were: (1) Agencies, including education, which influence people have not prevented or removed belief in signs and superstitions among students; (2) Senior high school students have heard of approximately half of the two hundred ideas in this study and on an average they believe in and are influenced by one-fifth of the ideas that they have "heard", (3) College students have heard of a greater number than the high school students, but believe in and are influenced by a considerably smaller number, (4) Weather proverbs and misconceptions

about natural phenomena rank highest; (5) About thirty of the two hundred unfounded ideas are the most prevalent and most influential: (6) Senior high school girls have heard, believe in and are influenced by a greater number of unfounded beliefs than are boys; (7) College women have heard, believe in and are influenced by a greater number of unfounded beliefs than are high school seniors of large cities.—C. M. P.

NATURE STUDY AND ELEMENTARY SCIENCE

School Subjects Which Elementary School Teachers Find Most Difficult and Those Which They Find Easiest to Teach. Mary R. Hollingsworth, Joy M. Lacey and J. R. Shannon. Journal of Educational Method, X: 75-83, November, 1930. This is the resumé of a questionnaire study involving 569 elementary teachers in some twenty-five elementary school systems in Indiana. Subjects were grouped under four headings of language, arts, mathematics, social studies and elementary science. The latter grouping included hygiene, physiology, health, nature study and geography. Language and composition, phonics, nature study and citizenship appear to be most difficult for primary teachers, while elementary science subjects are not given much attention as either being difficult or as being easy. Geography, history and civics, and language and composition were most difficult for intermediate grade teachers. Arithmetic and reading are found easiest to teach. Causes of difficulty of teaching showed wide variation among the subjects. Reasons given for difficulty in teaching nature study were: (1) insufficient knowledge of subject matter, (2) lack of any organized course of study to follow, (3) inadequate textbooks, (4) work in methods courses unrelated to actual classroom practice.—C. M. P.

Earth Sciences and the Children. Bertha Stevens. Progressive Education, VII: 326-333, November, 1930. The author describes the method and content used in organizing a two year elementary program for seven, eight and nine year-olds around the earth sciences as a central theme. Poetry, dramatization, drawing, modelling and language are a vital part of the children's activity. Topics dealt with are: the origin and movements of the bodies of the solar system; the phases of the moon and the tides; day and night; the year; seasons; spectrum; rainbow; meteorites; star distances and constellations; number and composition of stars; eclipses; composition of the earth; volcanoes; earthquakes; rocks; oceans; plains; deserts; forests; rivers; mountains; crystallization; atmosphere; weather; wind; clouds; forms of precipitation. Some attention is paid to plant and animal life. An attempt is made to give the child both an appreciation of the wonderful world in which he lives and an understanding of some of the important generalizations in science.—C. M. P.

GENERAL SCIENCE

An Experimental Study of the Daily Recitation Versus the Unit Plan. Arthur L. Shelton. School Review, XXXVIII: 694-699, November, 1930. Two classes, not specially selected, were taught by each method. Progress in four units of subject matter was determined by giving one form of a standardized test at the beginning of the semester and a second form at the close of the semester. The time spent on each unit was the same for each method. Neither method gave distinctly superior results.—C. J. P.

Report of the Sub-Committee on General Science. Francis D. Curtis. The North Central Association Quarterly, V: 410-437, December, 1930. This is a report of a committee whose purpose it was to evaluate certain general science topics in terms of the objectives of the North Central Association. The objectives used were: (1) the health ob-

jective; (2) leisure time objective; (3) the social objective; and (4) the vocational objective. The eighteen hundred-fifty topics of general science previously obtained from a synthesis of eighteen sources were evaluated by an elaborate statistical technique. The findings, based on the independent evaluation made of each topic by three secialists in the general science field, arc given in the rport. It was found that the subject mattter of general science contributed substantially to each of the four objectives, with the leisure objective ranking highest.—C. M. P.

General Science in the Eighth Grade or Not? E. J. Ashbaugh. Educational Research Bulletin, College of Education, Ohio State University, IX: 503-507, December 3, 1930. The comparison of the scores on two well-known general science tests attained by beginning ninth grade students some of whom had pursued science in the eighth grade while others had not showed no significant differences between the two groups. The two groups were paired by general intelligence tests. The findings raise certain questions concerning the significance of the tests and the instruction in general science.—C. J. P.

PHYSICS

Fluids in Motion. Adren Aitken. School Science and Mathematics, XXX: 1046-1051, December, 1930. An illustrated article covering the physics of the filter pump, baseball curves, the Venturi meter, atomizer and related phenomena.—E. R. G.

The Measurement of Color and Lustre as Applied to Textile Fabrics. A. Edwin Wells. School Science and Mathematics, XXX: 1005-1010, December, 1930. A worthwhile article for the physics teacher, showing some interesting applications of regular and diffuse reflection as applied to paper, enamel, silk and other textile fibres.—E. R. G.

Light Ray Reproduction of Sound. A. H. Gould. School Science and Mathematics, XXX: 911-919, November, 1930. This article is based on demonstration apparatus recently developed by the Central Scientific Company. A 400-watt projector is used with a siren disk driven by a variable speed motor. A photoelectric cell and amplifier completes the outfit. An interesting article for physics teachers.—E. R. G.

What is Light? Arthur H. Compton. Journal of Chemical Education, VII: 2769-2787, December, 1930. A summary of the major facts and principle theories by a winner of the Nobel Prize in Physics, illustrated with seventeen photographs and drawings. One of the best articles available for science teachers who wish a brief discussion of recent discoveries in the field of light.—E. R. G.

Modern Physics—A Survey. Part III. Saul Dushman. Journal of Chemical Education, VII: 2655-2663, November, 1930. This article discusses quantum mechanics and the Schroedinger wave equation and is the concluding section of an address given before the Science Section of the Tenth Ohio State Educational Conference. An article of great interest to physics teachers.—E. R. G.

College Student's Knowledge of Plane Geometry. H. J. Arnold. School Science and Mathematics, XXX: 894-900, November, 1930. This paper deals with the results obtained by giving the Schorling-Sanford Achievement Test. Eighty students, 90 per cent of whom were freshmen, were studied. Physics teachers will be interested to see the nature of the deficiencies shown by this rather detailed analysis. Many of the errors relate to arithmetic and algebraic deficiencies.—E. R. G.

CHEMISTRY

Rayon—Today and Tomorrow. Robert E. Hussey and Philip C. Scherer, Jr. Journal of Chemical Education, VII: 2543-2570, Novem-

ber, 1930. An extensively and beautifully illustrated article on the present state of the art with respect to rayon. Everything from rayon cobwebs to automobile upholstery cloth is included. Many photographs show factory processes. Production figures and geographical locations of factories are also included. The article closes with a two-page discussion of the future possibilities of the rayon industry.—E. R. G.

Scotland's Contribution to Chemistry. James C. Irvine. Journal of Chemical Education, VII, 2808-2828, December, 1930. A long article of unusual interest to teachers of chemistry and physics. Illustrations of Black, Hope, Thomson, Graham, Playfair, Williamson, Couper, Alexander C. Brown, Ramsay, Dewar, Murdoch, Young and Perkin are included.—E. R. G.

The Discovery of Synthetic Alizarin. Louis F. Fieser. Journal of Chemical Education, VII: 2609-2633, November, 1930. A valuable article for the chemistry teacher. Photographs of Graebe, Liebermann, Caro, and Perkins are included. Many interesting incidents are related concerning the work involved in this series of investigations.—E. R. G.

Visual Aids in Chemical Education. Journal of Chemical Education, VII: 2916-2927, December, 1930. This article in chemical education includes a list of film distributors with addresses, also a list of films classified according to subjects in the various fields of chemistry. Details are given also on the number of reels, width of film and whether the films are free, for sale or for rent. Every teacher of chemistry should study this list with great care, since it represents an enormous amount of work and has in it many valuable suggestions for making the science of chemistry a much more worthwhile one in the opinion of the average student.—E. R. G.

The Chemical Man. Hellmut Bauer. Journal of Chemical Education, VII: 2710-2711, November, 1930. A short article describing an exhibit used for the annual science exhibit at Hiram College. Worthy of the attention of chemistry teachers.—E. R. G.

A Small Laboratory Furnace. Eugene F. Coleman. Journal of Chemistry Education, VII: 2720-2721, November, 1930. An illustrated article on the construction of a small electric furnace that would be useful in any high school chemistry department.—E. R. G.

Chemistry Exhibits in the Small Laboratory. JOHN J. CONDON. Journal of Chemical Education, VII: 1649-1656, July, 1930. A description of students' exhibits of posters, commercial products and chemical processes in a Syracuse, New York, high school. An instructive short article on this phase of technique.—C. J. P.

A Plea for Mercy. EDWIN L. ROE. Journal of Chemical Education, VII: 1645-1648, July, 1930. This article raises the question as to the validity of standards of attainment set for high school chemistry and pleads that the teacher is not solely to blame for student's failure to reach the standards determined by college teachers or graduate students in science education. The author takes the old,thread-worn point of view that high school teachers are handicapped by the product sent them from the elementary school and condemns general science as "often worse than no science at all."—C. J. P.

The Teaching of Chemistry in the Schools and Institutes of France. MAURICE DESCHIENS. Journal of Chemical Education, VII: 1544-1549, July, 1930. The first part of this article briefly portrays the kind of chemistry taught in the schools in Latin countries. The first elements of the subject are given one hour weekly at about the seventh year to students of twelve to thirteen years. The method is largely demonstration. Students preparing for later science study

are given the chemistry that specifically prepares for entrance examinations of higher schools.—C. J. P.

Hydrogen Balloons. Guy M. Lisk. Journal of Chemical Education, VII: 2719, November, 1930. A new way to fill small rubber balloons with hydrogen from the ordinary high school laboratory generator. —E. R. G.

HEALTH

A Scientific Basis for Health Instruction in Public Schools. 1929. Laura Cairns. $1.25. University of California Publications in Education, Volume 2, No. 5. Berkeley, California; University of California Press.

This study considers first, the scientific determination of the proper content for health instruction in schools, and secondly, an examination in the light of the facts thus established of the health instruction given in public schools at the present time.

The material which should be included in health instruction has been determined by an analysis of the leading causes of mortality and morbidity, and of the incidence of minor ailments and physical defects, and from a study of the factors which authorities recognize as influencing these departures from the normal.

The first four chapters state the chief causes of death and of sickness and disabilities and following these statements in each case are listed the items of health instruction, a knowledge of which is necessary to prevent or reduce these conditions. The facts which should be taught have been listed and curriculum makers in the sciences, social sciences, physical education and health education may find here specific information to guide them in their further work.

The information gathered and tabulated has been used as a basis for comparing the health instruction given in the various schools, and for determining to what extent this instruction covers the essential items. Recommendations have been made which, if put into practice, will prove helpful in improving the health instruction in the schools.

The need for definite knowledge as to matters of health and for the application of that knowledge by the public is evident from the present high death rates, high morbidity rates, and the high incidence of physical defects. Practical application of scientific facts already known would reduce these high rates, but the mass of the people do not take advantage of this knowledge because they fail to realize the importance of prevention and control measures.

In attacking these problems it is therefore necessary to educate the public regarding the best known measures of reduction, prevention, and control. The schools are the best medium of education, since they reach the largest number of people, and since they can furnish students with definite scientific information that will enable them to cope with situations as they arise; but the public schools are not doing all they can in health education.

There is need for a better selection and a better organization of instructional content. Time which could be used to advantage in teaching essentials is too often wasted on the teaching of non-essentials.

Health instruction which fails to teach the fundamentals fails to function in health promotion. This failure is largely due to the fact that teacher-prejudices rather than scientific information determine health instruction.

The responsibility for health instruction is not always carried by those who should assume the major portion; that is, by the teachers of the fundamental sciences, who have the necessary foundation and facilities.

The chief responsibility for health instruction should not be placed on the physical education departments. They have other objectives than health education and cannot take the time from their activity programs to give pupils the scientific background necessary for intelligent health practices. Any attempt to assume this responsibility by groups other than those prepared to teach the underlying principles and having laboratories where the students may have first-hand experiences, results in dogmatic instruction.

In courses where laboratories are provided, there is a wide variation in the amount of time devoted to laboratory work. The instruction varies greatly and evidences a lack of effective standards.

In the elementary grades one of the main weaknesses is that too much time is spent on the teaching of non-essentials and many of the essentials are omitted.

In the junior high schools biology and general science, in the senior high schools physiology, biology, and general science include the greatest number of the essentials of health instruction.

The present survey shows, then, that except for physiology, biology and general science include more of the essentials of health instruction than any other subject. This would seem to indicate that biology and general science, since they are more widely offered than physiology, are best able to carry the major responsibility for health instruction. There is need, however, to put more emphasis on human biology and physiology.

Physical education, household science, physics, and chemistry, as well as other groups, have definite contributions to make to the health program. Each of these groups could make further contributions if the giving of health instruction were worked out according to a generally accepted plan. Because so many different subjects offer opportunities to work out a carefully organized sequence of subject matter for all, and at the same time, of course, to coordinate the efforts of the various groups in order that each may have a better understanding of the relation of his particular contribution to the whole. At present no sound general program was found.

There is a wide variation in the percentage of time given to health instruction in these contributory subjects. The present scheme permits a student to go through the public schools without any health instruction, or with but a limited amount. High schools, especially, lack a definite plan for health instruction. Comparison of the total number of students enrolled in classes offering health instruction with the total school enrollment shows that only a small percentage are receiving health instruction at any one time.—L. C.

DAYLIGHT AND FLOWERS*

Dr. W. W. Garner and Dr. H. A. Allard, plant breeders of the U. S. Department of Agriculture, have discovered an essential condition of plant growth and applied it to the raising of the Mammoth variety of tobacco. The objection to Mammoth tobacco from planters has been: seed for the next year's planting is difficult to get, as no flowers appeared upon the plant. The plant's energies seemed to go to the production of foliage. The problem of obtaining seed was finally solved by shortening the length of daylight, which readily caused the plant to flower. Now Florida raises the seed, as it possesses the right length of day, and Maryland planters grow the foliage. Length of daylight is the principle discovered and has been found to be one of the essentials of plant growth control, just as temperature and moisture are. Plants may be made to bloom at will by the application of this principle. Thus, to the chemical reaction controls, already much used, such as temperature, pressure, and concentration, is added light as a control condition. William J. Maddox

* Digest of article by E. L. Mattison in Tycos, 17: 4, 135-137 (1927).

Nature's Method of Purifying Polluted Water

In the study, by the United States Public Health Service, of the pollution of streams, it has been found that pollution (sewage, nonpoisonous industrial wastes, and similar polluting matter) when put into water is immediately attacked by bacteria which are so small that at least two millions of them could rest comfortably, side by side, on the head of a common pin. These minute organisms find the pollutional material a satisfactory food and increase rapidly in numbers. By this feeding process, oxygen dissolved in water is used up and the pollution is transformed into harmless bacterial bodies and by-products which are not putrescible.

At first it was believed that the bacteria, unassisted, could completely purify polluted water. This was found not to be the case, however. The bacteria multiply in the polluted water until a certain number of population is reached, the limiting number varying with the amount of pollution present. When the limiting population is reached, multiplication stops and the process of purification also stops, although considerable amounts of pollution may still be present. If the bacterial population of the water is reduced at this time, the multiplication and purification processes continue. To arrange for a continuous reduction of bacterial numbers, Nature, in her marvelous economic system, has provided some very small animals, called Protozoa, whose principal food appears to be bacteria. These bacteria-eaters, which are very much larger than bacteria, but yet so small that fifty of average size could lie on the head of a common pin, feed continuously on the bacteria.

In this manner Nature provides for the completion of the purification process, and the bacteria and the Protozoa in the water decrease in numbers as the amount of food available for each decreases.

The addition of any poisonous substance to the polluted water may slow up or, if sufficient amount be added, completely stop Nature's purification process, by killing off prematurely these industrious workmen.

A series of interesting papers describing the methods employed and the results obtained in these studies are being published in the Public Health Reports, under the general heading of, "Experimental studies of Natural Purification in Polluted Waters."

New Books and Monographs

Elementary Science by Grades—Book V—1930—Ellis C. Persing and C. Louis Thiele—309 pages. Book VI—1930—Ellis C. Persing and John A. Hollinger—340 pages—D. Appleton and Company, New York.

Books V and VI complete a series of six science readers entitled *Elementary Science by Grades*. Ellis C. Persing, Assistant Professor of Natural Science, Western Reserve University, Cleveland, Ohio, has collaborated with C. Louis Thiele, Supervisor of Exact Science, Detroit, Michigan, in writing Book V, and with John A. Hollinger, Director of the Department of Science, Pittsburg, Pennsylvania, in Book VI. Dr. Frank W. Ballou, Superintendent of Schools, Washington, D. C., has edited the series of books for the first six grades of elementary schools.

The content of each book is organized around a central theme. The subject matter of Book I relates to the changes that take place in plant and animal life with the changes in seasons. The central thought in Book II is the beauty of common plants and animals found in gardens, vacant lots, fields, parks, woods, and markets; the beauty of the heavens; and the beauty in various natural phenomena. Book III emphasizes the wonders of the world, such as those seen in the development of plants and animals; the homes built by animals; the care animals give their young; the light of the sun; and the wonders of magnetism. These three books have been written by Mr. Persing and Mrs. Peeples. Book IV, written by Mr. Persing and Mr. Edward E. Wildman, emphasizes the many ways in which living things are dependent for their general welfare upon each other and upon the physical environment.

The dominant thought expressed in Book V is the garden as a center of plant and animal life. In a fascinating and at the same time clear and concise manner, various plants and animals are discussed in their relation to the garden. A brief summary of the subject matter treated in this book considers the following:

1. Some enemies of the garden, such as cabbage worms, aphids, rabbits, hares, gophers, and weeds.
2. Some of the friends of the garden, such as ladybird beetles, praying mantids, tiger beetles, toads, frogs, earthworms, birds, and bats.
3. Flowers in the fall garden, such as sweet alyssum, sunflower, calendula, and dahlia.
4. Oaks and pines, important groups of forest trees.
5. Desirable trees for shade.
6. Wonders in the heavens as exhibited by the polar constellations, Orion, Hyades, Pleiades, and the Milky Way.
7. Formation of rocks and the formation of soil from rocks.
8. Ways in which heat helps man.
9. Simple machines, as illustrated in common toys with which children play.
10. Bacteria and molds, important plants.
11. Planning, planting, and caring for a garden.

In Book VI the central topic is conservation of plants and animals in their relation to the problems of modern life. The contents of this book may be summarized briefly as follows:

1. Conservation of bird life, based upon a study of birds.
2. Establishment of bird sanctuaries in various parts of the country.

3. Birds that perform important services to man, such as insect-eating birds, birds of prey, and bird scavengers of land and sea.
4. Wise protection of wild life.
5. Snakes as friends and enemies of man.
6. Conservation of plant life, such as forests, Christmas greens, and wild flowers.
7. The sun and its family.
8. Means of communication as shown by the telephone, telegraph, ocean cable, and radio.
9. The locomotive, a factor in modern transportation.
10. Ways in which the Weather Bureau aids in conservation.
11. Insects in their relations to conservation, such as the mosquito, fly, and various household insects.

At the opening of each chapter in Books V and VI, as well as in each book of the series, is a group of introductory questions which serve to stimulate a preliminary discussion and to direct pupils in their reading. Each chapter closes with a section entitled "Some things to think about," which includes different kinds of tests designed to test reading ability. Under the heading, "Some things to do," found at the close of each chapter, are suggested activities for the classroom and the home which are appropriate for pupils of the particular grade level for which the book is written. These books, as well as Books II, III, and IV of the series, are illustrated by excellent photographs and diagrams. Book I is illustrated by attractive drawings in color.

Books V and VI are excellent science readers. They are accurate in subject matter; are written in a clear and fascinating style; and are well adapted to pupils of grades five and six. They are valuable additions to the science literature for these grades. The series as a whole will serve as an excellent guide for those elementary schools which do not have an organized course in science.—F. G. B.

Workbook to Accompany Introduction to Science—1930—Otis William Caldwell and Francis Day Curtis—245 pages—70 illustrations—Ginn and Company, Boston.

As indicated in the title, this workbook is intended to be used with the text, *Introduction to Science*, by the same authors. The organization follows in detail that of the text. Each numbered experiment refers to a chapter in the text. In addition to the laboratory exercises there are 21 larger projects.

The organization of each "experiment" is as follows: (1) title of the experiment, (2) statement of the problem, (3) list of materials needed, (4) suggested procedure and observations, (5) space and directions for writing conclusions, (6) questions for class discussion.

The book is more nearly a laboratory manual for the textbook than a workbook, as the term workbook has been used in recent years. There are many helpful diagrams to aid pupils with laboratory exercises. Equipment used is simple and of the kind which can be obtained readily in most schools. A list of needed apparatus and supplies is to be found at the back. An unique feature is added in the forms for reports on science books at the end.

Test Book to Accompany Introduction to Science—Otis William Caldwell and Francis Day Curtis—1930—28 tests—113 pages—Ginn and Company, Boston.

This set of unit tests is made to fit the text and laboratory workbook of the same authors. Tests are furnished in both A and B forms. There are twelve of each. There is no test for the first introductory unit of the text and units XII and XIII, and XIV and XV of the text are combined in the tests. In addition there are four

"final examinations" of the objective type. The first of these covers units II, III and IV, the second units V. VI and VII, the third units VIII, IX and X, and the fourth the remaining units.

The authors have attempted to set up a complete testing and grading program for the teachers who use their text. There are spaces for recording scores and making graphic charts of pupil progress. In the front are elaborate directions for arriving at grades based upon the tests included in the books. It is feared that these directions are rather more elaborate in detail than most teachers are likely to follow through. Teachers are cautioned against using any set of previously determined measures as the sale means of arriving at either the development of pupils or of final achievement. Undoubtedly the tests in this book are far in advance of those homemade tests developed by the average teacher on the spur of the moment. Many teachers will find in them more accurate measures than they are now using and enormous conservers of time and energy in checking results. The active, independent type of teacher who has his own ideas about his instruction and wishes to grow as he develops his own teaching devices, may refuse to use such tests outright and yet find many valuable suggestions in them for improving the construction of his own tests.—RALPH K. WATKINS.

Directed Study Workbook for General Science—1930—Russel E. Bridges and William C. Lee—132 pages and 53 pages of tests—no illustrations—Rand McNally and Company, Chicago.

This book consists of a pupil's work-book in general science and twelve unit tests. The present volume is marked "Part One," and contains only the material intended for the first half of the course. The selection of content follows the pattern of recent texts and courses of study for the most part. A few units are off type, for example Uuit No. 1 on Home Environment, No. 5, Cleanliness in the Home (this is really the water unit), and Unit No. 10, Care of the Lawn and Garden. Titles indicate that the general theme of the organization is that of interpretation and control of the home environment. The selection of topics corresponds more nearly to the organization of Trafton's *Science of the Home and Community* than any other one thing in the field.

Part I consists of ten major units. The preface indicates that there are to be eighten in all. Each unit is divided into problems. There are seven items for each topic. These are (1) a problem to be solved, (2) page references to text-books, (3) a list of study questions, (4) a further list of questions, projects and reports, (5) applications in the form of questions, problems, reports, experiments, and surveys, (7) a space for writing summaries, outlines, notes, etc.

Each problem provides for A and B contracts for pupils. The general bibliography and the page references to texts will be found extremely useful to both teacher and pupil.

There are objective tests for each unit. The tests are bound separately and are perforated, so that each may be removed singly. Tests are carefully done and would seem to be both valid and reliable for the units taught. The authors have carefully pointed out the limitations of the tests in the directions to the teacher.

This is an interesting and worth-while attempt to improve the routine instruction in general science. The material should be carefully examined by teachers of the subject. It will be found quite useful if its content fits the course taught in a particular school. More material is included than it is probable can be covered in a single year. This is not an insuperable fault, as it permits the teacher some range of selection by the simple process of omission.—RALPH K. WATKINS.

CLASS-ROOM STOP CLOCK »

This valuable piece of classroom and laboratory equipment is excellent for obtaining the total time of a series of oscillations, swings or cycles as a basis for the accurate determination of periodic time. It is also valuable for checking such laboratory processes and operations as timing the flow of liquid period in viscosity experiments, the flow of current period in electric colorimeter experiments, the exposure period in photo and blue printing, etc. Dr. R. S. Minor recommends its use in his experiment on the Radius of Gyration.

It is in fact a large size stop watch, being started, stopped and reset in the same manner. Its diameter of 21 cm. makes it visible to everyone in even a large classroom. The large outside dial indicates up to 60 seconds, then repeats; the small inside dial registers up to ten minutes, then repeats. Runs for 36 hours on one winding.

In finely nickeled case with suspension ring - **$18.75**

MILVAY
SCIENCE
SUPPLIES
TRADE MARK REG. U.S. PAT. OFF.

Chicago Apparatus Company
1735-43 North Ashland Avenue, Chicago, Ill.

General Chemistry for Colleges—B. Smith Hopkins, Professor of Inorganic Chemistry in the University of Illinois—D. C. Heath and Company, New York—1930—757 pp.—$3.72.

It may seem trite to say that a textbook maker should have in mind a special group of students at a definite level for whom he prepares his material. Yet there are all too many technical books, classified as texts, which fail to be useful in class teaching on account of neglect to recognize this elementary presumption. The result is that many a student has completed a first course in chemistry with a bad taste because the text-book by which he was expected to supplement and elucidate the lecture material just failed to elucidate. It is doubtful whether a thorough treatise on Chemistry can at the same time be a good text-book. Its very thoroughness and completeness involves the student in perplexities and mazes of thought beyond his grasp. The baffling problems of research chemists are just no problems at all to a novice.

For these reasons, the present volume should find a welcome. It is designed for students of the maturity of college freshmen. It is written by a teacher who, for many years, has successfully struggled with the problems and perplexities of this class of students. There are several features of the book which make it notable as an introductory text for the college level.

In the first place, there is a sort of engaging style to the discourse not usual in texts of this kind. There is no attempt to talk down to the students, but rather the evidence that the author actually knows young people, their difficulties and their interests. In accord with this adaptation to students needs also is the abundance of tables and figures,—mostly carefully made line-drawings, which portray laboratory set-ups and commercial apparatus. The tables, numbering 55, are not grouped at the end of the book in an appendix but are located adjacent to the topics which they summarize or generalize. The 38 chapters are well balanced and comprise, on the average, 25 pages. This is well suited to unit study, especially in conjunction with the exercises frequently proposed. At the end of each chapter, too, is an up-to-date bibliography—not exhaustive, but carefully selected for wider reading and reference.

The plan of the book follows the usual lines with few exceptions. The chapter headings are for the most part elements or groups of related elements. Exceptional chapters however are: I. History of Chemistry; II. Modern Chemistry; III. Fundamental Conceptions; V. Metric System, Gas Laws, Kinetic Theory; VII. Valence, Nomenclature; IX. Solutions, Colloids; X. Atomic Theory, Gas Volumes; XVI. The Periodic System; XVII. Structure of Atoms, Crystals.

As would be expected from the notable activities of the author, there are excellent discussions of atomic structure, crystals, and the periodic relations of the elements. Another refreshing treatment is that of Carbon. This element appears in its place among the nonmetals and its compounds follow directly without apology for considering Organic Chemistry as an integral division of General Chemistry.

The commercial processes and the practical, vital aspects of chemistry are constantly connected to topics under consideration—not in a way to make them appear supplementary—but as the interesting, natural relationships of chemistry and life. Photographs are not too numerous, but those used are new, well chosen and seem actually to illuminate the text rather than merely to adorn it.

On the whole, the author has succeeded in producing what he set out to do—a thorough, readable, scholarly textbook of chemistry for college students. You will look in vain for any evidence of bias

An Important New Mathematics Series

JUNIOR HIGH SCHOOL SERIES IN MATHEMATICS

By FRED ENGELHARDT, PH. B., M. A., PH. D.,
Professor of Education, College of Education, University of Minnesota
and
MARY L. EDWARDS, B. S., M. A.,
Teacher of Mathematics, Roosevelt High School, Minneapolis, Minnesota

AIM OF THE SERIES This new series provides a unified course in mathematics for *three grades of the junior high school.* Each volume, however, is a complete text in itself and is so organized as to give the maximum instruction for a year's work. The series has been thoroughly tested out before publication and meets all standard requirements. The interdependence of the three phases of mathematics, namely, arithmetic, algebra, and geometry, together with measurements and statistics, are emphasized throughout. The student is constantly impressed with the practical nature of the subject he is studying.

SPECIAL FEATURES Drill and review exercises are provided for the class as a whole, or for any selected group or individual. Special diagnostic tests have been prepared to guide in directing attention to significant pupil difficulties in the mastery of various skills. Following these tests special drill exercises, designed for remedial work for the shortcomings discovered, are arranged for convenient use. All work is introduced through problems which are of special interest to children of the grade using the text. Provision is made for pupils of varying ability.

MATHEMATICS
Seventh School Year
Pupil interest is emphasized without sacrificing the acquisition of fundamental skills that are required.
Price 96c

MATHEMATICS
Eighth School Year
Definitely planned to bridge over the seventh and ninth year work. It was planned, also, to complete the practical requirements of the many pupils who do not go beyond the eighth year of school.
Price 96c

MATHEMATICS
Ninth School Year
Prepared to supply the need of a unified mathematics text for this year. For the teacher who prefers algebra for the ninth year, or a correlated course of algebra, geometry, statistics, and arithmetic.
Price $1.24

THE AUTHORS Professor Engelhardt is thoroughly equipped for such a practical series as this, having an unusually varied career in the application of mathematics to more practical subjects, as well as a distinguished educational record in the schools of New York, Ohio, Pennsylvania and Minnesota. He is the author of other successful textbooks. Miss Edwards has had experience as a teacher of arithmetic and mathematics in the small as well as in the large school systems.

D. APPLETON AND COMPANY
35 WEST 32nd STREET, NEW YORK, N. Y.

or one-sided interest. Professor Hopkins, quite modestly—too modestly—refrains from mentioning the discoverer of Illinium. However, the book leaves no doubt that the author is master of his subject and is a good teacher. In paper, print, binding, and in general workmanship the text is modern and attractive. It should have an enthusiastic reception.—R. E. HORTON.

A Text-Book of Botany—Revised 1930—Coulter, Barnes and Cowles—Volume I, Morphology, revised by John M. Coulter—310 pages—618 illustrations—$1.80—Volume II, Physiology, revised by Charles A. Shull—308 pages—87 illustrations—$1.80—American Book Company.

The selection of material in these college texts is appropriate to prepare the student for teaching or for investigation. It emphasizes fundamental facts and principles and provides an ample body of knowledge. No attempt is made to include the economic side of Botany.

The chapter headings in *Morphology* are: 1. Thallophytes; 2. Bryophytes; 3. Pteridophytes; 4. Spermatophytes; 5. Organic Evolution.

In *Physiology* the chapter headings are: 1. The material income of plants; 2. The material outgo of plants; 3. Nutrition; 4. Destructive Metabolism; 5. Growth and Movement.

The books are attractive, the drawings are excellent, the references valuable, and the pages are full of solid, stimulating, helpful material.

Teachers Manual and Key for Problems in General Science—1931—George W. Hunter and W. G. Whitman—250 pages—illustrations—$1.00—American Book Company.

The purpose of this manual is to save the teacher's time and to assist the inexperienced teacher by giving helpful suggestions. Each unit of the text is discussed; a little information is given about the colored plates, and suggestions or informations relating to the practical exercises. Answers are given to the self-testing exercises and fundamental concepts test. Suggestions for review, summary outlines, achievement tests, practical problems and other chapter-end teaching aids all receive attention.

The book opens with a chapter on objectives of general science and ends with lists of apparatus, useful publications, and visual aids.

Laboratory Exercises in Zoology—1930—William M. Barrows—104 pages—28 illustrations—World Book Company.

This a practical student's manual for classes in animal biology. Part 1 describes 30 laboratory exercises covering such topics as anatomy, cells, circulation, foods, enzymes, osmoses, sensory motor responses, respiration, reproduction, heredity, classification of animals and fossils. Part 2 tells how to carry out 23 different projects. This covers a wide field of activities, such as field collecting trips, demonstration of aquaria, a vivarium, raising mice, vinegar "eels," an ant nest, developing hens' nest, and collecting fossils.

Elements of Plant Science—1930—Charles J. Chamberlain—394 pages—321 illustrations—$1.90—McGraw-Hill Book Company, Inc.

This book is adapted for use as a beginning course in elementary botany in high school and college. Part 1 takes up structure and functions of seed plants. This may be done without the use of microscopes, but Part 2—development of plants from the lowest to the highest—cannot be successfully covered without microscopes. A helpful chapter on laboratory methods ends each of the two parts.

A Superintendent* Wrote This Advertisement

EVERYDAY PROBLEMS in SCIENCE

Pieper-Beauchamp

634 pages, $1.60

STANDARDIZED TESTS

for the

PIEPER-BEAUCHAMP TEXTBOOK

A series of tests covering all units of the textbook.

Major Ideas	Factual Tests
Forms A & B	Forms A & B

Per package of ten, 20 cents

"We find the *Pieper-Beauchamp* EVERYDAY PROBLEMS IN SCIENCE exceptionally well adapted to our needs. It is well organized, interesting, and the most teachable book in general science of which I have any knowledge.

"The standardized tests covering the units of work are entirely without equal anywhere in the educational world. They not only are splendid tests, but they also are the source of much enjoyment to the students."—

February, 1930.

* Name on request

SCOTT, FORESMAN AND COMPANY

CHICAGO ATLANTA DALLAS NEW YORK

Instructional Tests

in Chemistry in Physics in Biology

Here is the efficient means of increasing mastery of the fundamentals. These instructional tests have been carefully developed to cover the essentials of any first course in these three subjects. They are Glenn-Welton's *Instructional Tests in Chemistry,* Glenn-Obourn's *Instructional Tests in Physics,* and Blaisdell's *Instructional Tests in Biology.* Each of the tests consists of a series of unit tests to be given at intervals throughout the year. They represent a distinct improvement in teaching.

Send for complete descriptions

World Book Company

Yonkers-on-Hudson, New York — 2126 Prairie Avenue, Chicago

Boston Atlanta Dallas San Francisco Portland

Everyday Physics—1930—C. J. Lynde—577 pages—401 illustrations—$1.80—The Macmillan Company.

Everyday Physics is a text for first year physics, which is intensely practical. Principles are not slighted, but the everyday uses of physics are stressed first. Applications to the home predominate. This is due very likely to the fact that the text is a rewriting of an earlier text, Physics of the Household, by the same author. Some teachers will miss the customary metric units, but the author defends the general use of the English units since they are the ones met in everyday life. The book is attractive and contains the latest applications of physical science.

Experimental Chemistry—A. Fredrick Collins—276 pages—108 illustrations—$2.00—D. Appleton & Company.

This is a book which will attract the junior high and the senior high boy who likes to experiment. It is written and illustrated in a rather free popular style. Some of the experiments are suitable science club demonstrations, especially when combined with other reference material on the same topic. A boy will learn much about the chemical substances from a book of this type, even though he is not interested in studying his text-book.

Physics—1931—Oscar M. Stewart—770 pages—492 illustrations—$4.00—Ginn and ompany.

This is a revised edition and is for use as a college text-book. The improvements in this text over the old edition are three in number: (1) Rewriting or additions to increase its pedagogical value; (2) the introduction of material to explain recent developments, as photo-electric cells, home refrigeration, and sound reproduction; (3) An increase in the number of problems and a wide range in difficulty, allowing a wider choice in problems.

The illustrations are practically all line-cuts, many of them new ones. Many tables give important data. The book is divided into five parts: mechanics and properties of matter, heat, wave motion and sound, magnetism and electricity, light.

Electricity—1930—Elmer E. Burns—235 pages—207 illustrations—$1.75—D. Van Nostrand and Co.

This appears to be a book for beginning students in electricity at about the senior high school level. Principles are given with reference to practical applications. The main topics covered are: electric cells; magnetic effects of current; Ohm's law and electrical circuits; direct current-measuring instruments; measuring resistance; generators, direct current motors; electric power and power loads, alternating currents; A. C. motors; A. C. measuring instruments; current distribution. Ten useful tables are given in the appendix. It is a desirable reference book for general science and physics courses.

Elementary Heat—1930—W. F. F. Shearcroft—224 pages—89 illustrations—$1.25—Oxford University Press.

Part One gives a preliminary survey of heat sufficiently elementary for junior high pupils. It deals with fuel, temperature, change of state, change of size, measurement of heat, conduction, radiation, convection, weather, heat engines, and sources of heat.

Part Two covers most of the same topics in a type of cyclic treatment, yet they are viewed from a different standpoint. As may be expected, part two is rather more difficult, includes more mathematical treatment and emphasizes the underlying principles. On the whole, we consider this an excellent book, full of helpful suggestions for good teaching.